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Thesis

TREE CROPS OF THE DIFFERENT CLIMATIC REGIONS OF THE WORLD

by

Mary Emma Mrose

(B.S. in Ed., Salem Teachers' College, 1940)

submitted in partial fulfilment of the

requirements for the degree of

Master of Arts

1944

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TABLE OF CONTENTS

CHAPTER	PAGE
I. INTRODUCTION	1
Importance of Tree Crops	1
Meaning of Tree Crops	1
Classification of the Tree Crops	2
Organization of the Thesis	3
PART I. MAJOR GEOGRAPHIC FACTORS UNDERLYING THE DISTRIBUTION AND PRODUCTION OF TREE CROPS	
II. MAJOR GEOGRAPHIC FACTORS VS. TREE CROP PRODUCTION	5
Economic Factors	5
Supply and Demand	5
Labor	6
Time factors	8
Physiographic Factors	10
Location in Respect to Land and Sea	10
Location in Respect to Main Trade Routes	11
Location in Respect to Labor Supply	12
Soil	12
Topography	13
Political Factors	15
Climatic Factors	16
Rainfall and Humidity	17
Temperature	18

CHAPTER PAGE

Wind..... 19

Sunlight..... 20

PART II. CLIMATIC REGIONS OF TREE CROP PRODUCTION

III. TROPICAL TYPES..... 21

Tropical Humid Climates..... 21

Tropical Rainy..... 22

Monsoon Tropical (Tropical Savanna)..... 26

Cool Tropical Highlands..... 29

Arid and Semi-Arid Tropical Climates..... 32

Semi-Arid Tropical (Tropical Steppe)..... 33

Arid Tropical (Tropical Desert)..... 36

IV. SUBTROPICAL TYPES..... 40

Humid Subtropical..... 41

Mediterranean Subtropical..... 44

Dry Subtropical (Steppe and Desert)..... 47

V. CYCLONIC TYPES..... 51

Humid Continental Climates..... 51

Humid Continental--Long Summer Phase..... 52

Humid Continental--Short Summer Phase..... 55

Marine West-Coast Climate..... 59

PART III. TREE CROPS OF THE DIFFERENT CLIMATIC REGIONS

VI. TREE CROPS OF THE TROPICAL RAINY CLIMATE..... 64

Beverages..... 64

CHAPTER PAGE

Cocoa and Chocolate..... 64

Cola (Kola)..... 74

Drugs and Medicinal Products..... 74

Cajeput..... 74

Chaulmoogra Oil..... 76

Guaiacum..... 78

Quassia..... 79

Quinine..... 80

Dyes and Pigments..... 86

Annatto or Arnotto..... 86

Barwood and Camwood..... 87

Fustic..... 88

Gamboge..... 89

Logwood or Campeche..... 90

Sappanwood and Brazilwood..... 92

Fibers..... 93

Coir..... 93

Kapok..... 95

Piassavas..... 101

Raffia..... 106

Toquilla Fiber..... 107

Fruits..... 111

Avocado..... 112

Breadfruit..... 117

CHAPTER PAGE

The Carambola..... 119
The Durian..... 120
The Guava..... 122
The Lime..... 125
The Mango..... 127
The Mangosteen..... 133
The Papaya..... 135
The Sapodilla..... 139
The Tamarind..... 140
Gums and Resins..... 142
Gum Resins..... 142
Gum Elemi..... 142
Hard Resins..... 143
Copals..... 143
Dammars..... 147
Kinos..... 149
Oleoresins..... 149
Balsam of Peru..... 149
Balsam of Tolu..... 150
Benzoin..... 151
Copaiba..... 152
Styrax or Storax..... 153
Latex Products..... 154

CHAPTER PAGE

Balata..... 154

Chicle..... 157

Gutta-Percha..... 161

Jelutong..... 164

Rubber..... 166

Para Rubber..... 167

Panama Rubber..... 178

Assam Rubber..... 181

Lagos Silk Rubber..... 181

Masticatories..... 182

Areca or Betel-Nut..... 182

Cola (Kola) Nut..... 185

Nuts (Edible)..... 189

Brazil Nuts..... 189

Cashew Nuts..... 195

Coconuts..... 197

Paradise Nuts..... 198

Pili Nuts..... 199

Oils and Waxes..... 200

Fixed Oils..... 201

Babassu-Nut Oil..... 201

Borneo Tallow..... 204

Candle-Nut Oil..... 205

Carapa Fat..... 205

CHAPTER PAGE

Coconut Oil..... 206
Cocoa-Butter..... 214
Cohune-Nut Oil..... 214
Kapok Oil..... 216
Mowra Fat..... 216
Nutmeg-Butter..... 216
Palm Oil and Palm Kernel Oil..... 217
Volatile (Essential) Oils..... 222
Champaca Oil..... 222
Oil of Bay..... 222
Oils of Cinnamon and Cassia..... 223
Oil of Cloves..... 224
Oil of Copaiva..... 224
Oil of Pimento..... 224
Nutmeg Oil..... 224
Sandalwood Oil..... 225
Ylang-Ylang..... 225
Waxes..... 226
Raffia Wax..... 226
Spices and Flavoring Materials..... 226
Allspice..... 226
Cassia..... 228
Cinnamon..... 230
Cloves..... 233

CHAPTER PAGE

Nutmeg and Mace..... 237

Star Anise..... 241

Tonka Beans..... 242

Sugars and Starches..... 244

Palm Sugar..... 244

Sago Starch..... 248

Tanning Materials..... 249

Mangrove..... 249

Miscellaneous..... 252

Vegetable Ivory..... 252

VII. TREE CROPS OF THE MONSOON TROPICAL (TROPICAL SAVANNA) CLIMATE.....256

Nux-Vomica..... 256

Cutch..... 257

Red Sandalwood..... 258

Kadaya Gum..... 259

Shea-Butter..... 260

Divi-divi..... 261

Myrobolans..... 264

VIII. TREE CROPS OF THE COOL TROPICAL HIGHLAND CLIMATE.... 268

Coffee..... 268

IX. TREE CROPS OF THE SEMI-ARID TROPICAL CLIMATE.....277

Gum Arabic..... 277

Wattle Gum..... 280

CHAPTER PAGE

Ceara Rubber..... 280

Carnauba Wax..... 281

Wattle Bark..... 284

X. TREE CROPS OF THE ARID TROPICAL CLIMATE..... 289

The Date..... 289

XI. TREE CROPS OF THE HUMID SUBTROPICAL CLIMATE..... 296

Beverages..... 297

Maté..... 297

Tea..... 302

Cassine..... 316

Dyes and Pigments..... 317

Osage-Orange..... 317

Sumach (American)..... 318

Fruits (Edible)..... 318

The Feijoa or Pineapple Guava..... 318

The Fig..... 320

The Grapefruit..... 320

The Kumquat..... 320

The Lemon..... 323

The Litchi..... 323

The Loquat..... 327

The Mulberry..... 327

The Orange..... 327

The Peach..... 327

CHAPTER PAGE

The Persimmon..... 327

The Tangerine..... 327

Gums and Resins..... 327

Hard Resin..... 327

Lacquer..... 327

Oleoresins..... 328

Crude Turpentine..... 328

Oils (Fixed and Essential)..... 334

Fixed Oil..... 334

Tung Oil..... 334

Essential Oils..... 339

Camphor Oil..... 339

Oil of Petit-grain..... 343

Tanning Materials..... 345

Quebracho..... 345

Sumach (American)..... 349

Nuts (Edible)..... 350

The Pecan..... 350

XII. TREE CROPS OF THE MEDITERRANEAN SUBTROPICAL CLIMATE.. 355

Drug and Medicinal Products..... 355

Eucalyptus Oil..... 355

Fiber..... 357

Crin Vegetal..... 357

Fruits..... 357

CHAPTER PAGE

The Avocado..... 357
The Apricot..... 357
The Cherimoya..... 362
The Citron..... 365
The Fig..... 368
The Grapefruit..... 368
The Jujube..... 368
The Lemon..... 370
The Loquat..... 370
The Orange..... 370
The Peach..... 370
The Pomegranate..... 370
The Plum and Prune..... 374
The Tangerine..... 381
Gums and Resins..... 381
Hard Resins..... 381
Mastic..... 381
Sandarac..... 383
Storax or Styrax..... 384
Oils and Waxes..... 384
Fixed Oil..... 385
Olive Oil..... 385
Essential Oils..... 393
Almond Oil..... 393

CHAPTER PAGE

Bergamot Oil..... 393

Lemon Oil..... 394

Oil of Neroli..... 396

Orange Oil..... 396

Pistachio Oil..... 397

Walnut Oil..... 397

Spices and Flavoring Materials..... 397

Almond Oil..... 397

Apricot-kernel Oil..... 398

Lemon Oil..... 398

Orange Oil..... 398

Peach-kernel Oil..... 398

Pistachio Oil..... 398

Tanning Materials..... 398

Sicilian Sumach..... 398

Tanbark Oak..... 400

Valonia..... 402

Tree Legume and Edible Nuts..... 403

Tree Legume..... 404

The Carob..... 404

Edible Nuts..... 408

The Acorn..... 408

The Almond..... 410

The Chestnut..... 415

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

CHAPTER PAGE

The Filbert..... 420

The Persian or English Walnut..... 422

The Pistachio Nut..... 427

Miscellaneous..... 430

Cork..... 430

XIII. TREE CROPS COMMON TO THE HUMID AND MEDITERRANEAN SUB-TROPICAL CLIMATES..... 438

The Fig..... 438

The Grapefruit..... 443

The Lemon..... 448

The Loquat..... 453

The Mulberry..... 456

The Sweet Orange..... 466

The Peach..... 475

The Nectarine..... 481

The Persimmon..... 482

The Tangerine..... 485

XIV. TREE CROPS OF THE DRY SUBTROPICAL CLIMATE..... 487

Mesquite..... 487

Piñon Nuts..... 491

XV. TREE CROPS OF THE HUMID CONTINENTAL CLIMATES..... 494

Drug and Medicinal Products..... 495

Slippery Elm..... 495

Dyes and Pigments..... 496

CHAPTER PAGE

Quercitron..... 496

Fruits..... 497

The Apple..... 497

The Cherry..... 505

The Pear..... 509

The Plum..... 512

Gums and Resins..... 512

Oleoresins..... 512

Canada Balsam..... 512

Spruce Gum..... 514

Essential Oils..... 515

Oils of Juniper, Savin, and Red Cedar..... 515

Oil of Sassafras..... 517

Flavoring Materials..... 517

Oil of Juniper..... 517

Sassafras..... 517

Sugar..... 518

Maple Sugar..... 518

Tanning Materials..... 525

Chestnut Oak Bark..... 525

Hemlock Bark..... 527

Quercitron..... 528

Tree Legume and Edible Nuts..... 529

Tree Legume..... 529

CHAPTER PAGE

Honey Locust..... 529

Edible Nuts..... 531

Beechnuts..... 531

Black Walnuts..... 533

Butternuts..... 534

XVI. TREE CROPS OF THE MARINE WEST-COAST CLIMATE..... 536

Drugs and Medicinal Products..... 536

Cascara..... 536

Fruits..... 537

The Apple..... 537

The Cherry..... 537

The Pear..... 537

The Plum..... 537

Gums and Resins..... 538

Kauri Gum..... 538

Tanning Materials..... 539

XVII. CONCLUSIONS..... 541

XVIII. ABSTRACT..... 543

XIX. BIBLIOGRAPHY..... 548

CHAPTER I

INTRODUCTION

1. Importance of Tree Crops.

With man's advent on earth trees began to play an important role, for their nuts and fruits served as a source of food for him and his family. However, with the need for plants which would yield food crops in a hurry--not because of their productivity--primitive woman, the world's first agriculturist, domesticated annual plants such as wheat, barley, rye, oats, corn, and rice.[1] Thereafter, for centuries, man valued trees essentially for the tree itself, as a source of saw timber and woodpulp. Comparatively little attention and recognition has been given to the value of trees for the various crops which they produce. Therefore, in this thesis I have undertaken an extensive study of the major tree crops of the different climatic regions of the world to show man's present dependence upon them for his welfare and comfort.

2. Meaning of Tree Crops.

In this thesis I am primarily concerned with a presentation and evaluation of those tree crops which are the products of trees growing in natural forests, on plantations or native farms, or in cultivated orchards, and which are important not

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[1] J. Russell Smith, Tree Crops, Harcourt, Brace and Company, 1929, p. 11.

alone for their timber or woodpulp, but primarily for the crop or crops which the trees produce. Tree crops may consist of the fruits, nuts, beans, berries, flower buds, seeds, leaves, bark, latex, or juices of trees.

Some trees would never be grown by man were it not for the demand for the particular crops they produced. No one would grow cinchona trees were it not for the bark; or mulberry trees were it not for the leaves which are indispensable to the existence of the silkworm; or coffee trees were it not for the berries; or rubber trees were it not for the latex; or coconut trees were it not for the fruit.

Some tree crops are nature-willed products, being produced by the tree as part of its biological development and are obtained by a gathering method. Included as nature-willed products are such crops as fruits, nuts, berries, leaves, bark, and gummy exudations. On the other hand, in contrast to the nature-willed tree crops are the man-willed; that is, those tree crops not voluntarily yielded by trees, but produced as the result of man's interference. For instance, latex, gums, resins, and dyestuffs are man-willed products because the trees do not yield them for use except when man makes a deep enough cut in the bark of the tree.

3. Classification of the Tree Crops.

Tree crops readily lend themselves to several types of classification; but because of the economic treatment given

to them in this thesis, those of each of the climatic regions have been grouped under headings indicative of man's major use of them; beverages, drugs and medicinal products, dyes and pigments, fibers, fruits, gums and resins, latex products, masticatories, legumes, nuts (edible), oils and waxes, spices and flavoring materials, sugar and starches, tanning materials, and miscellaneous.

4. Organization of the Thesis.

The thesis on tree crops is presented in four major parts. The first deals with those factors underlying the distribution and production of crop-yielding trees and treats of the following: the economic factors,--the demand for the tree crops for domestic consumption and for foreign markets,--labor,--and the time factor as involved in the production of different tree crops for marketing; the physiographic factors,--location in respect to land and sea, main trade routes, and labor supply,--and topography, with emphasis upon the advantages of regions of rugged relief for crop-yielding trees; the political factors; and the climatic factors,--the effect of rainfall and humidity, temperature, wind, and sunlight in tree crop production. Because of the direct and indirect influences of climate on tree crop production, part two is devoted to an analysis of the different climatic regions in which tree crops are produced, with emphasis upon their effect on tree growth and crop production. Part three presents the tree crops of the different

climatic regions with a discussion of each as to their geographical distribution, the geographic factors underlying their production, their culture and preparation for market, and their economic importance. The fourth and last part consists of findings and conclusions resulting from the work on the thesis.

PART I

MAJOR GEOGRAPHIC FACTORS UNDERLYING THE DISTRIBUTION AND PRODUCTION OF TREE CROPS

CHAPTER II

THE MAJOR GEOGRAPHIC FACTORS VS. TREE CROP PRODUCTION

Climate is the fundamental factor which determines the possible geographic distribution of the crop-yielding trees for the different parts of the world. Their actual economic production, however, is ultimately dependent on the combined effect of certain economic, physiographic, political, and climatic factors. For this reason, though crop-yielding trees may be widely scattered geographically in a number of like climatic areas, their exploitation may be limited to only one or two of these regions and utterly disregarded, as far as economic production is concerned, in all others.

1. Economic Factors.

Supply and Demand. Economic conditions tend to limit or extend the areas of tree crop production. Importantly among these is the relation between supply and demand for a specific tree crop. The supply depends upon wild-growing trees or those cultivated on plantations, "native farms", or orchards; the demand, upon the economic uses of the tree crop. If the amount consumed on the market is limited, it does not pay to produce the crop under cultivation and then only the wild trees are exploited. On the other hand, if the uses for the tree crop are numerous, or new uses for it are found, it becomes a cultivated

tree crop and its area of production may be greatly extended.

As substitutes enter the world markets to replace the crops produced by trees or new inventions extend the life of the product, an oversupply in comparison to the demand may result. In such cases, where much land has been devoted to plantation production of tree crops, a surplus results and the price goes down, until it does not pay to produce the crop. As a result of this condition, the area of commercial production can be reduced until it may become smaller than that in which the tree crop is physiographically available.

Labor. The character and abundance of the labor supply is a powerful economic factor in the geographical distribution and production of tree crops. Wherever there is an abundance of cheap labor, tree crops may be produced at such low costs that it enables the product to be sold in the world markets at very low prices. On the other hand, where scarce or expensive, labor may be the prohibitive factor in tree crop production.

The character of the laborer is an important consideration in tree crop production. Willing, patient, intelligent, and skilled workers are needed to furnish products of high quality. These qualities depend largely on the race, training, climate, and health of the people. In tropical South America, for example, the native Indians are extremely poor workers. The native negroes of tropical Africa are a little better than those of tropical South America, but they are still very inefficient.

In contrast to these two are the people of southeastern Asia--the Malay Peninsula and parts of the East Indies--who are industrious, efficient, intelligent. Because of the efficiency of the people in the latter region, plantations of tree crops have been established here rather than in tropical Africa or South America even though in a number of cases these last two have been the original home of the tree crop,--i.e., rubber, quinine.

In temperate regions the local labor supply often determines for which of a tree's possible crops the tree is primarily cultivated. For example, the mulberry tree furnishes two crops, leaves and berries. In the Orient where the standard of living is low due to overpopulation, the tree is cultivated for its leaves which form the basis of sericulture; in the United States where the standard of living is high, this same tree is cultivated for the berries which fall to the ground upon ripening and furnish excellent forage for pigs and poultry. In the former region the plucking of the leaves requires an abundance of cheap labor, while in the latter, no labor is required for harvesting the berries.

The centralization of tea production in the Oriental countries is a good example of the effectiveness of labor in restricting commercial production of a tree crop to certain regions. The tea tree will grow in regions of Humid Subtropical climate. It can, therefore, be grown in southeastern United

States where that type of climate prevails; but because of the absence of a cheap, abundant labor supply in the United States, tea could not be profitably grown in competition with that produced in China, Japan, or India where there is an abundance of cheap, efficient, patient workers.

Only when the tree crops command high prices can they be profitably cultivated or produced in regions where the native labor supply is expensive, scarce, or unavailable.

Time Factors. Several time factors must be given careful consideration in determining the selection of a tree crop for cultivation on plantations or in orchards.

Crop-yielding trees are perennials, living over a period of years, in contrast to the life span of annuals which is measured in terms of months. Some crop-yielding trees have a life cycle from a few years--as in the case of the peach tree--, to several decades--as in the case of coffee or rubber trees--, and even several centuries--as in the case of the cork oak, the olive, and carob trees. Moreover, the life cycle of the crop-yielding trees must be analyzed and divided into distinct phases, each of which is of economic significance--the gestation period, the age commercial bearing begins, and the duration of bearing. The commercial bearing may be defined as that which pays the share of all expenses, including the overhead of production.[2] The gestation period differs, sometimes greatly,

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[2] Erich W. Zimmerman, World Resources and Industries, Harper and Brothers, Publishers, 1933, p. 388.

from the age of commercial bearing. Using the apple for analysis of these time factors, it will be found that the gestation period is from four to seven years, while the commercial bearing age is twelve years; the corresponding ages for coffee are three to four years, and five to six years, respectively; for rubber, five to six years, and eight to ten years, respectively.

The gestation period involves two economic considerations. First, this period involves unremunerative waiting. If a plantation or orchard is started, the investor must be prepared to wait a number of years--dependent upon the tree--before his investment can be expected to provide worth-while returns. During that period of waiting he is advancing considerable sums; in addition, such periods of waiting necessitate long-range demand anticipation--often speculative anticipations. Very often this may be over-estimated or underestimated due to unforeseen changes in demands during the long gestation period of the tree. Thus, by the time the gestation period is ended, the owner may turn out to be a prince or pauper.

Producers of tree crops employ several devices in order to alleviate the difficulties in prolonged unremunerative waiting periods. Young orchard fruit trees are frequently grown in nurseries before being set out in their final place in the orchard, thus reducing the period during which the orchard land is not earning a return on its investment. In other regions catch crops--as in coffee regions of Brazil--are planted, here-

by providing means for the laborers to grow food and feed crops among the young trees. These catch crops may be also found on mature plantations in times of financial difficulties.

In addition, because of the long gestation period the producer of tree crops is handicapped by the fact that his investment must yield returns over a long period of time to make his venture financially successful. Another handicap of a long gestation period in tree crop production is the inability of the owner to adjust his acreage to meet unfavorable market developments. Such adjustments are more readily made by the farmer who produces annual crops or those who raise short-lived crop-yielding trees than by those who raise long-lived perennials, such as coffee or rubber trees.

2. Physiographic Factors.

Location in Respect to Land and Sea. Wherever regions of crop-yielding trees are located near the sea, especially in the tropics, they have the advantage of ease of transportation. Since most tropical regions which furnish the rest of the world with tree crops lie at great distances from their markets, it is necessary that these crops be shipped across the seas. If they must be carried far by land before reaching the seaports, the cost of transportation eats up the profit. Transportation by water is cheap. Therefore, a location near a navigable waterway and within reasonable reach of a good seaport is especi-

ally valuable. Thus, if two regions both produce the same tree crop, the one whose location is nearer the sea has the geographic advantage which may cause it to eclipse the other in commercial production for the demands of world markets. For this very reason the production of cinchona bark from trees on the plantations of the islands of the East Indies, particularly Java, is far more important than that from the native wild trees of the eastern slopes of the Andes. The former region was able to assume first place in cinchona production because of its insular and peninsular character, which gave the plantations there greater accessibility to seaports; the latter region with its great distance from the seaports on the eastern coast of South America (the Andes serve as a transportation barrier to any possible western ports) has been forced to relinquish its former importance as a cinchona producing district.

Location in Respect to Main Trade Routes. Location near main trade routes where ships visit or pass at frequent intervals fosters tree crop production within that general vicinity even though that region may in actual mileage be farther than another from the centers of demand. The location of the East Indian region on one of the world's main trade routes has been responsible for the extensive development of plantations of various crop-yielding trees in that part of the world. The infrequency of regular visitations by ocean ships to ports along the coasts of South America and Africa--areas by no means so

far from the United States and western Europe as the East Indian region--has been responsible for the limitation of plantation crop-yielding trees within their boundaries.

Location in Respect to Labor Supply. The production of tree crops necessitates a labor supply for cultivation, harvesting, preparation for marketing, and marketing. Regions close to centers of dense population have the advantage of an everpresent source of cheap labor which can be drawn upon, and so there the production of tree crops is not interrupted by a lack or scarcity of labor. Moreover, where the workers are few in number, it is difficult to gather enough of them at any one place to solve any labor problem in connection with the production of a tree crop. The labor supply of South America and Africa is less numerous than that of the Far East. Thus can be found another explanation for the establishment of plantations of crop-yielding trees requiring a steady supply of cheap labor in the East Indian region of the world.

Soils. Each crop-yielding tree has its own peculiar soil preference. Most of these trees possess a wide range of soil adaptability, but any and every kind of land cannot be used for their cultivation. The character of the soil--its fertility, humus content, depth, texture, and porosity--influences the size, health, and longevity of trees and determines the flavor and quality of tree fruits.

Usually much more important than the mechanical or chemi-

cal composition of the soil is the drainage. Sticky, heavy soils through which water does not readily percolate are, under ordinary circumstances, avoided by most trees. Fruit-bearing trees are particularly exacting in this requirement; the trees do not fruit profitably if the subsoil is permanently wet or poorly drained. The mangrove tree is a conspicuous exception to the demand for good soil drainage; it thrives best in regions where its roots are covered by water at all times.

Soils which are suitable but for fertility can be improved to meet the requirements of specific crop-yielding trees either by the application of fertilizers or the cultivation of cover crops.

Topography. Tree crops are grown successfully and profitably in regions of gentle and rugged relief. Areas with rugged relief, however, have certain advantages over regions of gentle relief in tree crop production.

In both humid and arid regions mountain slopes intercept rain-bearing winds. Where these mountain slopes face the prevailing winds, the air has to rise to get over them. As a result, such slopes receive rain more regularly at all seasons than adjacent flat areas, or slopes which face the other way. Within the tropics the steady trade winds which blow from a more or less easterly quarter during the tropical dry season bring rain to the properly exposed slopes, even when other places are dry and so allow tree crop production on the slopes

whereas their growth on adjacent lowlands may be prohibited by the lack of sufficient rainfall during the tropical dry season. Even in the middle of the Sahara the high mountains intercept the rain-bearing winds and squeeze moisture from them to support pistachio trees on the slopes.

Gentle slopes are sought as sites for the establishment of plantations in the tropics; they provide better soil drainage and are not as likely to be water soaked as flat lands, a condition which causes trees to suffer from root rot and other fungus diseases.

Perhaps the most important advantage of slopes is that they provide good air drainage which greatly decreases the hazard of frost. At night the rapid cooling of the earth's surface chills the adjacent air. The cool air becomes relatively heavy and moves slowly down the slopes, and settles upon the floor of the valley or plain, usually far from the slopes of the mountains, leaving warmer air on the slopes. Thus, the danger of frost is less on the slopes than in the low places. In spring and fall a difference of from 5° to 15° F. may be found between flat lowlands and neighboring slopes. Because of the relative freedom of slopes from frosts, slopes are preferred as sites for the establishment of fruit orchards in the temperate regions.

Tree crops can be raised almost as cheaply on slopes as on land that is level. Hence, in many regions orchards are usual-

ly located on slopes and the level ground is left for vegetable and grain crops. Many of these slopes are too rugged for agricultural use as measured by the plainsman's standards, but support dense populations by growing such trees as the olive, chestnut, and pistachio. Similarly, the apple orchards of the northern Ozarks and southeastern Ohio stand out as oases of prosperity in the midst of comparative agricultural unproductivity. Tea culture on the wet hill lands of the Orient and the growth of mulberry trees in the densely populated lands of Japan and China are also profitable uses of hill country. Nut trees have perhaps the greatest advantage of any of the tree crops for slope lands since they require less cultivation and fertilization than fruit trees, and the transportation of the nut crop costs little because of its lightness in comparison with its value.

3. Political Factors.

Though a region may be climatically favorable for the growth of certain tree crops, whether or not they are exploited for export in some instances is controlled by existing political conditions. In a country subject to frequent revolutions the production of tree crops becomes spasmodic and unreliable; but where political stability prevails, outside interests are more willing to invest their money in the establishment of plantations or render assistance of one kind or another in the development of existing tree crops. Also, a government which is

non-cooperative and imposes heavy taxes on the tree crop exports merely for the sake of adding to the treasury balance turns prospective purchasers to other producing areas, thereby robbing its native people of economic security.

Wars also influence the location of tree crop production as well as the amount of production. Temporarily, at least, wars cause regions within the war sphere to be eliminated as producers for world markets. Under such circumstances countries, finding themselves deprived of certain tree crops by war activities, often seek substitutes or synthetics to replace the original. Thus, by the time a war ends and a region is ready to resume production of its tree crops, it may no longer find a demand for it.

4. Climatic Factors.

Each crop-yielding tree has its own particular set of climatic requirements which limit the areas where it can be grown profitably. Each has a certain optimum climate in which it thrives better than under any other conditions. In addition to the climatic optimum there is both an upper and lower limit to be considered for each tree crop. The climatic optimum and limits differ for each crop-yielding tree. The climatic limits on tree crop production include rainfall and humidity, temperature, wind, and sunlight.

Rainfall and Humidity. Crop-yielding trees grow all the way from the tropics to the Arctic wherever moisture conditions are favorable. Each has its own optimum and limits of rainfall and humidity. Some thrive best only where the rainfall averages over 80 inches a year; others, where it averages less than 10 inches a year. Trees which thrive in the former will not grow in the latter, and vice versa. Most trees will not grow where the ground is usually saturated, but the mangrove requires such a condition. Trees are not usually found where the rainfall is less than 20 inches unless irrigation or underground water is available. Thus, trees have a dry limit and a wet limit.

Profitable production of certain tree crops requires an even distribution of moisture throughout the year; others prefer that the rainfall occur at particular times with reference to blossoming, setting of fruit, ripening of fruit, or harvesting.

Tree crops requiring a high amount of moisture do not always demand an accompanying high humidity. For this reason, irrigation can be satisfactorily employed in regions of low rainfall in producing tree crops which require a high moisture content but which do best where the humidity is low. Through irrigation the distribution of tree crops--particularly fruits--has been greatly extended.

Temperature. Chief among the limiting factors of climate on tree crop distribution and production is temperature. Each crop-yielding tree has its optimum temperature condition as well as its cold and warm limits. Where the temperatures are too high or too low, the tree crops diminish in both quality and quantity. As they approach their optimum climate, they improve in both quality and quantity.

Tropical tree crops, in general, require a year-round growing season and so are limited in distribution to regions in which there is an absence of frost throughout the year--where the average temperature of the coolest month is over 64.4° F. Subtropical tree crops are able to withstand a short winter season during which occasional frosts occur--where the average temperature of the coldest month is between 64.4° F. and 33.8° F. The temperate tree crops are produced where a definite winter season ranging from 3 months to 7 months occurs each year--where the average temperature of the coldest month is under 33.8° F., and the average of the warmest is between 50° F. and 64.4° F.

Tree crops have a warm limit as well as a cold limit. The sugar maple, for example, is rarely found south of latitude 40° and even there does not give a good supply of sap. The southern limit of the apple tree roughly coincides with the average summer temperature of 79° F.; if grown where no frost occurs, the tree will not produce flowers and fruit, for fruiting re-

quires exposure of flower buds to frost.

Because the climatic optimum of fruits is close to the poleward limit, many desirable tropical fruits have been introduced into the subtropical regions; here the frost problem is being solved by the employment of orchard heaters. Other subtropical and temperate fruits are grown beyond their natural isothermal boundaries in regions having favorable slope locations or proximity of large bodies of water whose tempering influences help reduce the danger of frost occurrence and damage.

Wind. Wind is a climatic limit with reference to tree crop production. Strong winds and wind storms are harmful. The sites of fruit orchards, in particular, must be chosen with great care to avoid being in the path of regular strong winds which may damage the blossoms, fruit, branches, or entire trees. This is particularly true for Florida and the West Indies where hurricanes are often experienced and expected. Cacao culture is restricted to the floors and lower slopes of protected valleys because the strong, steady trade winds which blow over the regions of cacao production otherwise might cause the heavy pods to drop from the tree, or increase transpiration and cause the pods to dry up and produce poor "beans". Cork stripping is never done when the hot drying winds common in the Mediterranean area--the Sirocco--are blowing; such winds cause undue drying of the tender inner bark exposed by stripping and no new

cork will form.

Sunlight. Too much or too little sunlight sets a limit on the production of certain tree crops. Cacao trees are sensitive to strong sunshine with the result that shading is necessary; shade trees are often planted so they will tower above the cacao trees and protect them from the direct rays of the sun. Other crop-yielding trees--like the coffee tree when grown on the tropical lowlands--require shading from the vertical rays of the sun only during the early years of growth. On the other hand, many trees demand an abundance of sunshine and will not grow or fruit where the sunlight does not reach all parts of the tree.

The amount of sunlight occurring during the length of days at certain seasons influences the production of fruits. Many trees form flower buds for the next year's fruit only when the hours of daylight are short in autumn; so if cultivation of fruit trees is attempted where the days in autumn are long, no flower buds will form. For this reason, temperate fruits are unsatisfactory in subtropical and tropical regions. Thus, the length of day may set an upper and lower limit to the distribution of certain tree crops.

PART II

CLIMATIC REGIONS OF TREE CROP PRODUCTION

CHAPTER III

TROPICAL TYPES

1. Tropical Humid Climates.

The tropical rainy climates form a broad equatorial band around the earth, extending beyond the Tropics of Cancer and Capricorn in some areas, although not reaching them in others. Contrary to two common notions, as a whole tropical humid climates are not excessively hot.

On the whole, the greatest amount of annual rainfall occurs in the equatorial belt, decreasing both northward and southward; but even where the rainfall is high, 100 inches or more, most of it comes as heavy showers, often in the late afternoon or night, and brilliant sunshine prevails during most of the day. Contrary to belief, temperatures are not excessively high. During most of July higher temperatures usually occur in the interior of the United States than are ever encountered in most places near the equator. On the other hand, there is no cold period, and the humidity is high. These factors give rise to a monotonous climate, warm and humid month after month, which proves enervating.

Within the belt of warm, humid climates three major cliatic types may be recognized, each extending over large areas. They are: 1) The Tropical Rainy, where all the months are

warm and rainy without any pronounced dry season, and where the daily and annual ranges of temperature are slight; 2) The Monsoon Tropical (Tropical Savanna), with pronounced wet and dry seasons and low range of temperatures; and 3) The Cool Tropical Highlands, having all-year warmth but with distinctly seasonal rainfall and marked diurnal range of temperature. Each is of such importance that it warrants detailed study of its climatic characteristics, its regional distribution, and geographic relationship to crop-yielding trees.

Tropical Rainy. The Tropical Rainy Type of climate is distinguished from other tropical humid climates by its heavy rainfall, continual dampness, and absence of a pronounced dry season. Here there is no distinctly dry season--merely a less rainy one. All the months have high temperatures, about 80° F. while the daily and annual ranges of temperature are slight. There is a total absence of frost.

In general, regions having this type of climate are located in the equatorial belt, ranging only a few degrees north and south of the equator except for some narrow coastal strips which extend nearly to the tropics. The three largest and most typical sections which are included under this classification are: 1) the East Indies and the adjacent portions of southeastern Asia, involving the Malay Peninsula and the lower slopes of the mountain ranges of India and southeastern Asia where they face the southwest summer monsoon; 2) equatorial lowlands of the

Congo Basin and the Guinea Coast of Africa; and 3) the equatorial lowlands of the Amazon of South America. The Congo Basin and the Amazon Lowland owe their climatic character chiefly to their location near the equator wherever the doldrum rain occurs practically throughout the year. Smaller areas with essentially the same type of climate occur along the eastern coasts where the trade winds blowing onshore from warm oceans are forced to ascend mountains or highlands, as in parts of Central America and the West Indies, eastern Madagascar, or where a combination of convectional rain of the equatorial type in summer and of trade wind rain at other seasons provide the necessary moisture, as at the eastern base of the Andes.

The temperatures of these areas are not exceptionally high, averaging about 80° F. all the year round at sea level. Monotony of temperature conditions is the dominant feature. Seasonal changes are, therefore, very slight; the difference between the average temperature of the warmest and the coolest month rarely exceeds five degrees. The diurnal range is usually much greater than the annual range, but in some localities the nights are less than ten degrees cooler than midday periods. Temperatures above 90° F. are not common, but on the other hand even coolest nights seldom drop to 60° F. and for long periods night emperatures of 75° F. or more may prevail.

The Tropical Rainy Type of climate is characterized by winds and calms. Surface winds, on the whole, are light

and variable. Squalls and thunderstorms of short duration occur frequently. The destructive storms often associated with tropical climates are not characteristic of the all-year rainy areas; this is a factor of great economic significance for tropical crop-yielding trees of commercial value.

Humidity in this climatic region is generally high, in many areas averaging 80 per cent or more with periods of 90 per cent not being uncommon. The total annual rainfall is above 80 inches. The rain comes at quite regular hours during the day, mostly as heavy showers which are of short duration. These showers are succeeded by brilliant, almost dazzling sunshine. The more prolonged rains occur at night, but the latter part of the night time is not rainy and the morning hours are usually clear. Such a condition necessitates the gathering of latex from the rubber trees during morning hours. This combination of high temperature and heavy rainfall causes dense forests to cover everything.

However, parts of the Tropical Rainy Type have a longer period when less rain occurs. Here a wet tropical agriculture is carried on to advantage as a result of the occurrence of a less rainy season. The coastal lowlands of southern India, the lowlands of Java, the coastal regions of eastern Brazil, some West Indian islands, and coastal portions of Central America and Mexico are involved in this classification. In some of these regions natives were encouraged to established clearings

for tree crop agriculture, and contracts were made to buy all the natives could raise. In others, plantations of tree crops were brought under direct foreign control with natives working under white supervision. Thus plantations of such tree crops as rubber, cacao, oil palm, and coconut were established to meet the demands of world trade and commerce, and have become an important phase of tropical agriculture.

Owing to the heavy rainfall and relatively high temperatures throughout the year, the soils of the Tropical Rainy regions are subject to continual and vigorous leaching. They are therefore usually deficient in most or all of the essential plant foods. Thus, for successful production of tree crops on plantations liberal applications of fertilizer are desirable and often necessary, and careful methods of tillage must be employed if productivity is to be maintained for more than three to four years after the clearing of the virgin forest.

Other handicaps in addition to climate, dense forests, and generally poor soils is the prevalence of plant and animal pests and diseases. Such warm, humid climates with their total absence of frost are conducive not only to an abundance of insect life, but also to the development of fungi and all sorts of micro-organisms. Commercial crop-yielding trees of various kinds have been ruined because of the attack of some disease against which the scientist has proved powerless, as, for example, the coffee plantations in parts of the Far East which

were destroyed by a fungus attacking the leaves, and the cacao plantations of Ecuador which are threatened with destruction by the dreaded witch broom disease. Entire districts in parts of Central America have had to abandon banana production because of the ravages of blight. Furthermore, fungi and insects quickly attack stored products unless precautionary measures, usually expensive, are vigorously carried out. In addition, many tropical products are highly perishable under such climatic conditions and must be marketed promptly to avoid deterioration.

Tree crops of the Tropical Rainy regions are of two types: 1) those gathered by the natives from trees growing wild in the rainforest; and 2) those produced either by the natives themselves on a small scale in clearings made by them in the forest, or by large commercial organizations from middle latitudes which operate highly organized estates and plantations on a large scale and along the most modern scientific lines, specializing in products for world market. Tree crops representing the former type include such well-known products as Brazil nuts, wild rubber, balata, tagua nuts, palm nuts, toquilla palm fibers. A few characteristic of the latter type are plantation rubber, quinine, cacao, coconuts, and oil palm.

Monsoon Tropical (Tropical Savanna). The Monsoon Tropical Tropical Savanna climatic region is characterized by a long rainy season and a short but pronounced dry season. The chief difference between this climatic region and the Tropical Rainy

is the distinctly seasonal distribution of rainfall, although in general the total amount of precipitation in this case is less also. Not only is the total rainfall less than in adjacent tropical rainforests but is less dependable. Thus, seasonal and annual drought is a major problem in this type.

A study of a climatic map indicates that the Tropical Savanna climate is probably more extensive than any other. It occurs to the north and south of the Tropical Rainy areas, thus marking the first stage in the gradual transition from rainy to dry. Principal areas associated with this climatic classification includes: for Africa, it occurs across southern Sudan, most of Mozambique, parts of East Africa, to the south of the Congo Basin in Rhodesia and Angola, and northwestern Madagascar; for South America, it holds sway over the great central Brazilian Campos or Matto Grosso and the Llanos of Venezuela and Colombia (occupying the Orinoco Basin), and the Gran Chaco of Bolivia and Paraguay; in Australia, it puts its stamp only on the northern coast; in Asia, it characterizes most of the Deccan Plateau of India, besides smaller regions in Burma and Thailand (Siam), and parts of the East Indies and the Philippines; in North America, it extends over most of the West Indies, the west coast of Central America, and most of both the east and west coasts of Mexico.

The Tropical Savanna climate extends far enough north and south of the equatorial zone to include large portions of the

the trade wind belts. The rainy season occurs during the high-sun period and the dry season is during the low-sun period.

Temperatures are similar to those occurring in the Tropical Rainy regions, the chief difference being a somewhat greater seasonal range. In general, no month averages below 65° F. As a rule the highest temperatures immediately precede the period of maximum rainfall. The rains are accompanied by lower temperatures and thus bring relief from the excessive heat of the preceding weeks.

The extreme monotony so characteristic of the Tropical Rainy Type is not present here because of the range of temperature and humidity, and the climate is therefore much more conducive to physical and mental activity.

Although the rainfall is abundant, it is not excessive. The annual precipitation varies from 30 to 60 inches for different regions, the former being so low that, because of the all-year warmth, it results in a condition bordering on semi-arid. Marked seasonal distribution is the most prominent feature of the rainfall. The length of the rainy season varies from 8 to less than 5 months; the dry season increases in duration with the distance from the equator.

The soils of this climatic region are yellow or reddish. They belong to the group of lateritic soils, and as such they are weak in humus and soluble mineral plant foods. The savanna soils are not so thoroughly leached as are the soils of the

rainy tropical because here the rainfall is not so heavy and so they have a somewhat better physical structure. The soils of the equatorward areas are more thoroughly leached than are those of the areas which lie further from the rainy belt. Therefore, the soils of the drier parts of the Tropical Savanna rank higher in fertility than do those of the rainier areas and are more easily tilled.

This type of climate has certain advantages: the dry season gives man more energy than is the case where all months are warm and rainy; the rainy season is the growing season while the dry season is the harvest time, and the dry air which marks it favors complete ripening of crops.

The dry season of this region limits the vegetation to heavy grass and scrub forests with scattered trees, mainly of a thorny nature. Trees of this climatic region furnish such tree crops as gums, waxes, resins, and tanning materials. In the Gran Chaco of South America the quebracho tree with its wood full of tannin is one of the few important resources of the open forest of the Tropical Savanna.

Cool Tropical Highlands. The contrast between the tropical highlands and lowlands is due largely to temperature. The Tropical Highlands differ from the lowlands in having somewhat lower average temperatures and great daily rhythm of temperature. Most of the areas included in the Tropical Highland Type of climate lie at altitudes between 2000 and 6000 feet above sea level

with several notable exceptions where greater heights are reached, as in Ethiopia and southern Mexico.

The largest area typical of this type of climate is in Africa, involving the high plateau region which extends from Lake Victoria southward and eastward across the headwater districts of the Congo and Zambesi Rivers, involving the plateaus of Tanganyika, Kenya, and Uganda; others include the high plateaus of Ethiopia, the highlands of South Africa in Rhodesia, and interior Madagascar. Outside Africa important high plateaus include those of the Andes, southern Mexico, Yemen in southern Arabia, Yunnan in southern China. Highly important are the lower tropical plateaus such as those of southeastern Brazil and Central America.

The outstanding feature of this type of climate is its cooler temperatures in comparison with those of the adjacent lowlands. Temperatures are moderate, characterized by diurnal rhythm which does much to relieve the monotony of small seasonal changes. The average annual temperatures range from about 65° F. to 72° F., and the difference between the mean of the warmest and coldest months of the year is often less than 10°. However, there is a fairly pronounced difference between the temperatures of day and night. The days are warm to hot and clear, while the nights are usually cool enough to be quite invigorating.

The rainfall, though usually ample, varies in different

regions from about 30 inches in some, up to 80 inches in others; but 30 to 60 inches per year may be considered a fair average for most parts. The seasonal distribution of rainfall is conducive to tilling the land and harvest of crops. At the time when the vertical sun is farthest away, then there is little or no rain; when the midday sun approaches the zenith, a rainy season begins, lasting for several months. In areas south of the equator the rainy season lasts from October to April, while the driest month is July. Opposite conditions prevail north of the equator.

The dominant winds are the trades. Not only do they bring moisture to these areas but their steady breezes render living conditions more pleasant and bring a desirable freshness to the atmosphere. Climatic conditions are quite favorable for human activities, the people such as inhabit the highlands of eastern Brazil and southern Mexico being more progressive than in the adjoining lowlands.

The soils are partly red and yellowerths similar to those of the rainier sections of the savanna lands; others have similarity to tropical blackerths, especially where rainfall is low and a grass vegetation prevails. This latter type of soil is very fertile. It is a noteworthy fact that the most extensive and successful coffee plantations supplying most of the world's commercial coffee are located on the reddish soils of the highlands. These soils are derived from igneous rocks and are rel-

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atively fertile. Taken as a whole, the soils of this climatic region resemble those of the humid savannas, but are generally less leached, more readily tilled, and more productive. However, the application of a commerical fertilizer or planting of cover crops is necessary except where active weathering serves to furnish the soluble minerals essential for plant growth.

The Tropical Highlands are perhaps the best "white man's lands" in the tropics, but they are handicapped economically in that their products must compete with similar products raised nearer the great world market. The one outstanding exception to this general statement is coffee production, and for this reason the Tropical Highlands are sometimes spoken of as the world's coffee lands.

2. Arid and Semi-arid Tropical Climates.

Climate may be classified as dry wherever the rainfall is insufficient to support tree growth. Although other factors may contribute to the absence of trees, aridity is the fundamental cause for the existence of most of the treeless areas in the warm climates. On each side of the equatorial belt (rainy), in latitudes 20 to 30 degrees north and south of the equator, lie belts where little rain falls. These dry belts crossed by the Tropics of Cancer and Capricorn are often referred to as the tropical desert areas. The middle portions are extremely dry, in places almost rainless, and are bordered by semi-arid

belts which mark the transition to the humid climates farther north and south.

Where the rainfall suffices to support only grass turf, or scanty bush or shrub vegetation, the climate is classified as semi-arid. Where the rainfall is so slight that the sparse vegetation is dormant most of the time, where the landscape is characteristically brown, rather than seasonally green, there is the desert, a product of the Arid Tropical Type of climate. Although the amount of annual rainfall is not always a reliable criterion, the deserts of the tropics generally have less than 10 inches of rain per year, while semi-arid lands receive an average annual rainfall of 10 to 20 inches.

The rainfall in the Arid Tropical Type is slight and irregular; the landscape is brown or gray, except when infrequent rains give rise to brief periods of green. In the Semi-arid Tropical Type, where the rainfall is somewhat heavier, the short grass or scattered shrub vegetation presents a green landscape for a few months each year.

Since the term desert is universally recognized as a name for dry lands, it is so used in all latitudes. It seems justifiable to use the term steppe in similar manner for semi-arid lands, whether they occur in middle or low latitudes.

Semi-arid Tropical (Tropical Steppe). This climate has, like the Tropical Savanna, a wet and dry season, but the dry season usually lasts more than half a year. The exact bound-

ary between the Tropical Steppe and Tropical Savanna is where the amount of evaporation equals the amount of rainfall.[1]

The largest areas of these warm, semi-arid lands occur in Africa: the northern Sudan, which extends entirely across the continent from Senegambia to Somaliland; and the Kalahari steppes. In Australia the semi-arid belt borders the arid interior on the north and east, being the transition zone between the rainier coastal strips and the almost rainless interior. In South America the most extensive area of warm, semi-arid land lies in eastern Brazil where much of the basin of the São Francisco River suffers from insufficient rainfall. Smaller areas occur in northern Argentina and southern Bolivia--the Gran Chaco--and in southwestern Ecuador. In the Northern Hemisphere the most typical areas of warm, semi-arid steppes include much of Lower California and part of the Plateau of Mexico.

The most prominent features of the Tropical Semi-arid Type are the low annual rainfall, usually less than 20 inches, and its distinctly seasonal distribution. The dry season lasts from six to nine months, with some months practically rainless. The rainy season is generally associated with the high-sun peiod of year, while the drought is most intense during the low-

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[1] Klimm, Lester, Otis P. Starkey, and Norman F. Hall, Introductory Economic Geography (Sec. ed.), Harcourt, Brace and Company, 1940, p. 106.

sun period. Both the Tropical Savanna and Tropical Semi-arid lands have summer rains and winter drought; the difference between the two is one of degree rather than of kind.

Temperatures, on the whole, show a greater seasonal rhythm than in any of the more humid climates thus far discussed, being due chiefly to the greater distances from the equator at which the dry steppe lands occur, although greater dryness of the air is also a contributing cause. The hottest season of the year usually occurs during the high-sun period, just before the rains begin.

During the high-sun periods the warm, semi-arid climates are characterized by variable winds and light rains, mostly of the convectional type. During the dry season the trades prevail, being dry parching winds which give rise to a hazy, dusty atmospheric condition.

Since in the Semi-arid Tropical climate the rainfall is insufficient to produce heavy leaching, the soils are generally rich in lime and other minerals. On the whole, the soils of the steppes of the tropics average fairly high in potential productivity; their mineral content is ample, their structure is stable, and they are easily tilled. The chief problem of these climatic areas is one of water supply rather than of soil fertility.

Although varying considerably in their aspects from one place to another, regions of this climatic type possess a na-

tive flora of scattered thorny bush or short grass, while along the permanent and intermittent water courses some trees occur. What trees are found growing naturally usually have thick bark and narrow leaves, nature's protection against excessive evaporation.

Arid Tropical (Tropical Deserts). The climatic map demonstrates clearly that the largest extent of dry deserts lie in the relatively low latitudes, and that most of the great deserts are in the vicinity of the Tropics of Cancer and Capricorn. The Tropical Deserts constitute a sort of dry divide between the rainy lands of the low latitudes and those of the middle latitudes. Furthermore, their location is poleward from the areas of Semi-arid Tropical climates.

There are seven important areas involved in the Arid Tropical Type of climate: the Sahara Desert stretching from Rio de Oro and French West Africa eastward across Africa to involve Algeria, Egypt; the Kalahari Desert in southwestern Africa; the Thar and Arabian Deserts of Asia; the Victoria Desert which forms a large part of Australia; the Atacama-Peruvian Desert of South America which involves a narrow strip along the Pacific Coast from Ecuador through Peru and Bolivia to Chile; the Colorado-Sonoran Desert which borders the Gulf of California in North America. These tropical deserts extend roughly from latitude 18° to latitude 31° in each hemisphere, lying entirely within the horse latitudes or in the trade winds, and usually

in positions where the winds reach them only after blowing over lands for long distances or after crossing high mountain barriers. With one exception all tropical deserts are on the west side of continents.

Deserts are practically rainless. Rain is rare but important. What rainfall there is is irregular as to occurrence and often torrential as to volume, coming in the form of short, intermittent, heavy showers whose waters sink into the ground and nourish subterranean streams which supply the wells with water and form oases in depressions. Wherever mountains occur in desert areas there is increased rainfall there.

Any locality in the desert having a permanent supply of water from springs, surface streams, or ground water sources is termed an oasis. These "water islands" are infrequent and irregular in occurrence in arid lands and are eagerly sought as loci of agricultural adjustment. Oases vary in size from small one-family "irrigated islands" to huge areas such as Egypt, which is probably the most famous of all oases. In the oases of the old-world deserts there has been developed a two--or even three--layer horticulture. The upper tier is formed by tall date palms, beneath which stand the second tier composed of rows of low apricot, orange, olive, pomegranate, or peach trees.[2] The upper two tiers generally are tree crops. How-

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[2] George T. Renner and C. Langdon White, Geography: An Introduction to Human Ecology, D. Appleton-Century Company, 1936, p. 71.

ever, the date palm is the dominant tree of tropical deserts. It yields such an abundant food with so little care, and grows well not only in intense heat but in soil which is more or less saline. Tree crops of one or two tiers are found in the Imperial Valley--the great American oasis of Arizona-Sonoran Desert,--the Nile Valley in the Sahara, the valley of Shat-el-Arab and the valley of the Tigris-Euphrates which creates a large oasis in the Arabian Desert. The Sind is a significant oasis in northwestern India, but no tree crops exist there. The Victoria Desert has no large oases because of its deficient water supply. The Kalahari offers considerable possibilities for irrigation in the Lake Ngami district, but so far no large development has been undertaken. The Peruvian portion of the Peruvian-Atacama Desert has been considerably developed with irrigation projects, but no tree crops have as yet been established there.

Temperatures and winds in Arid Tropical regions are subject to fluctuations similar to that of rainfall. The changes in temperature from day to night are greater in most cases than are the changes from season to season. The range of daily temperatures from the warm season to the cool is rarely more than 30° to 40° F. On the other hand, daytime temperatures above 100° F. are not uncommon, while at night the temperature may drop nearly to the freezing point. Thus tropical deserts illustrate an extraordinary daily range of temperature.

Desert soils are often rich and productive when watered.

They are usually rich in soluble minerals because the light rainfall which falls results in little or no leaching. In shallow depressions where water may gather following heavy showers, the soils are often crusted with mineral salts that are unproductive even under irrigation.

CHAPTER IV

SUBTROPICAL TYPES

Poleward from the areas of tropical climates lie belts classified as subtropical, which differ from the tropical in having a winter season. Though it is mild with only occasional frosts, the cold season is sufficient, nevertheless, to give relief from the hot weather which occurs during a large part of each year. In general, the summers are long and warm; the winters are cool but not severe.

Subtropical climates may be divided into three types: the Humid Subtropical, which usually is to be found on the east coasts of continents between latitudes 20° and 40°; the Mediterranean Subtropical, which usually occurs on the west coast of continents between latitudes 30° and 45°; and intermediate between these two types lie the lands where the Dry Subtropical prevails, exhibiting some characteristics in common with its neighbors, but, being entirely an inland or interior development, it possesses certain unique traits. The essential difference between the Humid Subtropical and the Mediterranean Subtropical lies in the amount and distribution of the rainfall. In the Humid Subtropical, although there is a rainier period in summer, the rainfall is usually adequate throughout the year. In direct contrast, in the Mediterranean regions most of the rainfall occurs during the cool season; and because it receives

so little rain during the summer irrigation must be practiced. These two types may be considered to form a belt of transition between regions of relatively stable atmospheric circulation and dependable weather of the tropics, and those of unstable and often highly irregular circulation and changeable weather of the middle and higher latitudes.

1. Humid Subtropical.

The east coast regions with the Humid Subtropical climate include the following: for the northern hemisphere, southeastern United States (Cotton Belt) and southeastern China; for the southern hemisphere, in the region around the Rio de la Plata in South America, southeastern Africa, and southeastern Australia--the last two being confined by mountain ranges to a narrow zone along the coast.

In these regions the summers are hot and oppressively humid. Because of the warm summer nights and the high humidity, the summers in this climatic belt are enervating.

The winter temperatures average 45° to 55° F., but in the cooler half of this region cold waves cause killing frosts which occasionally do great damage by penetrating into the warmer half. On the whole, the winter season is mild and much vegetation remains green even throughout the coldest months. In the United States and China the most distressing features of winter are the cold waves which are experienced occasionally.

Within regions of this climatic type the winds are generally light and variable. In the summer the winds of the trade wind character are dominant. As winter approaches, the trades retreat; the westerlies follow and encompass these regions in the cooler portions, but only partially so in the warm. In southeastern China the inblowing monsoon dominates the summer, while the outblowing monsoon winds rule in winter. Because of this feature the climate of China is less true to type than elsewhere, the winter being dry and cooler whereas in other regions the winters are short, mild, and rainy.

During the latter part of summer, tropical hurricanes occasionally reach the coasts, causing serious damage to tree crops. They constitute a menace to orcharding. Since these late summer storms are most likely to occur when many tree crops are approaching the harvesting stage, losses resulting from their visitations often reach high figures. Damage to cultivated tree crops are especially serious because very often the trees as well as their crops are destroyed.

On the whole, the annual average rainfall in regions of Humid Subtropical climate is heavy, ranging from about 35 to over 60 inches. Furthermore, the rainfall is somewhat more evenly distributed throughout the year. Such condition is, all other things being equal, favorable for tree growth.

The soils typical of the Humid Subtropical are the red and yellowerths. Equatorward the soils are distinctly reddish,

while in the poleward portions they have a yellowish color. Because of the high rainfall, the soils are so fully leached that they are weak in lime and other soluble mineral salts, and, therefore, they entail heavy costs in labor and fertilizers if productivity is to be maintained. The most productive are, in general, the alluvial lands.

Favorable climatic and physical conditions exist for the growth of trees and the production of a variety of tree crops in all but one of the Humid Subtropical regions, treeless Uruguay being the sole exception. Southern United States is an important source of forest products. Practically all the naval stores and much tannin comes from these southern forests, from almost pure stands of longleaf pines. In South America this climatic region furnishes yerba maté whose holly-like leaves provides the most popular and widely used beverage in northern Argentina. Quebracho, the world's leading source of tannin, is procured from the Chaco, especially near the Parana and Paraguay Rivers. Relatively well-forested Natal supplies the black wattle tree, the bark of which is used for tanning leather. The lacquer and camphor trees give rise to important tree crops in southern Japan and Taiwan. Nut crops favored by Humid Subtropical conditions are the pecan in southeastern United States, and the tung-oil nuts in some of the provinces of southern China and the southeastern states of the United States. A variety of fruits round off the tree crops furnished by trees in various of

the regions of this climate--peaches, loquats, figs, citurs fruits, kumquats, litchis, and pineapple guava.

2. Mediterranean Subtropical.

In sharp contrast to the Humid Subtropical is the Mediterranean Subtropical Type of climate, lying on the west coasts of continents between latitudes 25° and 45°, and characterized by wet, mild winters and hot, dry summers.

This subtropical climate reaches its most extensive development along the northern and southern margins of the Mediterranean Sea. There the west coast climatic conditions prevail for an east-west stretch of over 2000 miles extending from southern Portugal and Spain to Palestine. Other regions having similar climatic conditions occur in southern Africa, southern Australia, central Chile, and southern California. All have the common features of rainy winters with possibility of frosts and summer droughts.

The three most strongly marked characteristics of this climate are: 1) most of the rain falls during the mild, cool winter--about 20 inches or less; 2) summers are intensely hot, dry, and sunny, giving a period of drought; and 3) the seasonal range of temperature is moderate so that typically the winters are mild and summers, quite hot.

Mediterranean Regions can scarcely be said to possess a winter, for the low-sun period is cool rather than cold. While light frosts are common during the cool season, killing frosts

are rare. Thus, the growing season is usually twelve months long. Nine of these months are warm to hot with the daily range of temperature being considerable, varying from 15° to 20° F.

The Mediterranean Type is characterized by variable winds. Occasionally the lands of this type are subject to scorching winds which originate in those hot dry lands. When these storms set in during the blossom time of olives or other fruits, or at the time of the stripping of cork bark, the year's crop of fruit may be ruined or the life of the cork oak may be endangered.

Topography is an important factor in soil development in all the regions having the Mediterranean Subtropical climate. A study of a map reveals that these regions have steep mountain or plateau slopes and relatively narrow plains in the valleys and along the coasts. Extensive areas of low relief are lacking. The topography generally consists of steep sloping uplands flanked by strips of detritus-built plains at the bases of the slopes. Topographic conditions imply the presence of eroded or skeletal soils on the slope lands and soils of depositional origin on the low plains. Active erosion tends to prevent the development of normal mature soils on the slope lands, and active deposition by wind or water prevents their development on the lowlands.

Because of the low rainfall, leaching is slight. The prevailing high temperatures are conducive to weathering, and therefore the soils are well-supplied with products of rock decay--namely, dry and soluble mineral salts. Humus, however, is not abundant due directly to the sparse native vegetation which consists of shrubs and trees rather than grass. Because the colors of the soils are brown and red, the term brownerths and brownish rederths are used to designate these soils.

Within these regions exist highly productive soils--the immature lowland soils which represent an accumulation of fine particles washed down from the slope lands and deposited without much loss of soluble mineral content along the stream valleys or as piedmont plains at the foot of mountains. It is here that vegetation flourishes more abundantly than on the higher and drier slopes. Water, however, is the great need. Where this is supplied, as in southern California or in the irrigated valleys of Mediterranean lands, abundant harvest of fruits result.

Two general types of land utilization characterize the agriculture of lands having the Mediterranean Subtropical climate; the extensive, dry-land type; and the intensive irrigated type. The former includes fruit culture, figs and olives leading. The latter includes the moisture-loving crops, such as give high returns per acre, among them being citrus fruits. These two types are in sharp contrast, the one involving exten-

sive land holdings, and the other, use of small acreages.

The native trees are evergreens which are able to grow during the winter season. During the summer months, however, they are exposed to the burning sun and therefore must protect themselves against extreme loss of moisture. As a result, most of them have either narrow, needle-like, hard, leathery leaves, often thick with fine hairs to restrict evaporation, so as to prevent too great loss of moisture; large, widespread, and often deep root systems to assist them in obtaining enough moisture for the tree in the dry season; and thick bark to retard evaporation.

3. Dry Subtropical (Steppe and Desert).

The Dry Subtropical Type of climate prevails in interior regions in the Subtropical Zone, lying intermediate between the Humid Subtropical and the Mediterranean Subtropical climates. Its intermediate location is responsible for its possession of characteristics common to its neighbors--very short winters which are cool rather than cold, and long hot summers, with only moderate changes in weather conditions; but its inland development causes it to possess certain differing traits.

The Dry Subtropical climates occupy inland positions on all continents except Antarctica, roughly between latitudes 25° to 40°. There are seven specific regions classified as Dry Subtropical: the Spanish Plateau; within the Atlas region of north-

ern Africa; the Turko-Iranian region of southwestern Asia; the Southwestern Plateau of United States and the Northern Basins of Mexico; the Andean section of northwestern Argentina; the High Veldt country of South Africa; and the Murray-Darling Basin of Australia.[1]

In amount, the average annual rainfall here varies usually from less than six inches in most places to tne inches in others. Most of this rainfall comes in short convectional showers in summer, though there may be small amount of rain in winter of cyclonic origin. Because of their interior location and the fact that they are practically surrounded by mountains which prevent the inflow of moisture-laden winds, they are in the rain-shadow of mountains and so receive only limited amounts of rain.

Diurnal and seasonal ranges of temperature are pronounced; the maximum in summer is comparatively high, with the result that those on lowlands resemble those of Arid Tropical climate. However, though the days in summer may be hot, the nights are cool. The temperatures on the highlands are cooler and often pleasant. Winter temperatures are low, usually only a few degrees above freezing, but are of short duration, lasting from

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[1] George T. Renner and C. Langdon White, Geography: An Introduction to Human Ecology, D. Appleton-Century Company, 1936, p. 144.

two to three months. Freezing temperatures at night persist later in spring and begin earlier in fall than is generally the case in humid climates of the same latitude.

The soils of this climatic type are generally the gray desert soils which are somewhat stony and of rough texture because the sharp changes of temperature cause disintegration of rock by mechanical processes. The dryness and coolness retard the chemical processes and slows up decomposition. Low rainfall causes but little leaching and since so much of the sink-in returns to the air by surface evaporation, the dissolved mineral salts are not carried away but are left in the upper part of the soil. The soils here are rich in soluble alkali minerals, sometimes so rich that plant growth is impossible; but they are low in humus because of the scantiness of the vegetative covering resulting from the low rainfall for most of the area involved in the Dry Subtropical climate.

The deficiency of rainfall is the one dominating cause of low productivity of the land, the other factors being of little significance. Wherever the rainfall is better or irrigation is possible to provide oases, crop-yielding trees exist though only in limited areas and in limited numbers. The piñon, a pine producing edible nut-like seeds, grows naturally in plateaus of southwestern United States.[2] On oases in the Salt River Valley

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[2] C. Langdon White and George T. Renner, Geography: An Introduction to Human Ecology, D. Appleton-Century Company, 1936, p. 146.

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5. Compton, Buie and George T. Hanner, Geography: An Introduction to Human Ecology, D. Appleton-Century Company, 1936, p. 145.

in southwestern United States and at the eastern foot of the Andes in northwestern Argentina may be seen typical Mediterranean tree crops of oranges, grapefruit, apricots, pears, plums, and peaches.[3]

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[3] C. Langdon White and George T. Renner, Geography: An Introduction to Human Ecology, D. Appleton-Century Company, 1936, p. 154.

CHAPTER V

CYCLONIC TYPES

The Cyclonic, or so-called Cool "Temperate", Types of climate lie poleward from the Subtropical Types. Regions lying within this climatic influence possess a hot season, a cold season, two intermediate seasons, and, in addition, exceedingly variable weather due to a constant succession of cyclones and anticyclones. Cyclonic Types differ from those of the Tropical and Subtropical in that here "weather is more outstanding than climate".

Within this general climatic zone there are such significant differences in precipitation and temperature that it is necessary to subdivide it into the Humid Continental and Marine West-Coast Climates.

1. Humid Continental Climates.

The Humid Continental regions comprise so great a sweep of territory and extend over so large a range of latitude, that many climatological variations occur within its realms. Two general sub-types may be recognized within this type which is characteristic of east coasts of continents between approximately 36° and 55° North Latitude: 1) Humid Continental-Long Summer Phase--the equatorward portions with long summers, which possess narrower seasonal temperature variations, receive more rainfall,

and exhibit a greater evaporation rate; 2) Humid Continental-Short Summer Phase--the poleward portions with short summers, possessing a wide range of seasonal temperatures.

Humid Continental-Long Summer Phase. The humid continental regions having short cold winters and long hot summers are limited to North America and Eurasia. In the United States this type of climate roughly coincides with the areas where corn and soft winter wheat are the leading agricultural crops--from 38° N. to approximately 42° N. In Europe it includes most of the drainage basin of the Danube River and part of the Polish Plain. In Asia it embraces northern China and Chosen.

The average temperature of the coldest month is below 42° F., but not much more than three months have averages which drop below freezing. The average temperature of the warmest month is at least 36° higher than that of the coldest month, and in many places the difference is even greater. These extremes are generally not so severe as to cause serious discomfort. On the contrary, the seasonal amplitudes are stimulating to mental and to physical activity.

Light frosts may occur during the early and late weeks of the growing season which varies in length from 150 to 240 days, but ordinarily these frosts are not injurious to the major crops. In the southern sections the winters are mild, but along the northern borders subzero weather is likely to occur during the coldest month. Throughout most areas periods of cool to moder-

ately cold weather are likely to be interrupted by severely cold spells each winter. The areas most remote from the sea, where continentality is pronounced, are characterized by periods of severe cold in winter and intense, sometimes devastating, heat in summer.

In North America and Europe this climatic type is dominated by the cyclonic storm conditions of the prevailing westerlies, but in eastern Asia the summer and winter monsoons are so strongly developed that they partly conceal the moving highs and lows. These cyclones and anti-cyclones which dominate the weather in this region move fairly regularly, in general from west to east, bringing a constant alternation of clouds, rain, and variable winds during the cyclones, and sunshine, fair weather, and westerly winds or calms during the anti-cyclones. These cyclones and anti-cyclones move faster and are more intense and numerous in winter than in summer, and their paths swing farther south then. So at all seasons the cyclones provide sufficient rain, and in large sections the rainfall in all months is practically the same.

The average annual rainfall varies from about 20 inches in the drier areas to 50 inches in the rainier sections. In general, the amount of rainfall varies inversely with the distance from the sea. Summer maximum of rainfall is prevalent nearly everywhere in the humid continental climate with long hot summers, but decidely dry winters are typical only of the American

interior west of the Mississippi and of northern China.

The predominant soils are the brownerths and gray-brown-erths. In these, leaching has not been quite so pronounced as in those of humid subtropics, partly because of lower annual rainfall and partly because during the winter season the ground is frozen for some time, thus making the water in the soil inactive. The lower annual temperatures and particularly the seasonal cold, account for less effective oxidation than in warmer climates, and therefore the soils are brown, rather than red. In the eastern and southern portions of this climatic region in the United States where the winters are generally mild and the rainfall is fairly heavy (40 inches or more), the soils are more thoroughly leached and the color is somewhat deep-brown. Toward the interior of the continents occur the prairie soils (prairi-erths) and chernozems. The prairi-erths are transitional between the brownerths and the chernozems; the chernozems are the world's de luxe soils (black earth), and have many good qualities. They require little, if any, fertilization and do not tend to become leached or acid, since the rainfall is not sufficient to carry dissolved material beyond the reach of deep-rooted plants. The prairie soils possess most of the good qualities of the chernozems, though poorer, and have the advantage of being more varied as to amount and kinds of crops produced because of the greater rainfall.

On the whole, the regions of Humid Continental-Long Summer

Phase are favored with soils of high agricultural potentialities. Only on mature soils are mineral fertilizers needed, but their responsiveness is such that moderate amounts suffice to insure good yields of crops.

The dominant native flora consists principally of deciduous forest in the more humid sections, and tall grass in interior areas of lower rainfall with trees there only along stream courses. The forest is principally of the mixed hardwood type, with oak, hickory, chestnut, and ash predominating. Pines are found on some of the more sandy lands, but pine forests are not so extensive as in the warmer region to the south or in the colder region to the north. In better areas fruit orchards exist to furnish tree crops.

Humid Continental-Short Summer Phase. This type of climate lies north of the Humid Continental-Long Summer Phase. It prevails in north-central United States from South Dakota eastward, north of the Corn Belt, and extends northward to include south-central Canada, from 42° N. to 60° N.latitude. In Eurasia the short, hot summer phase is well-developed in a broad belt which extends from eastern Poland and the Baltic states across central Russia into southern Siberia. An area of similar climate occurs in Manchukuo. As was the case with the Long Summer Phase this climate is not represented in the Southern Hemisphere.

The characteristics of the two humid continental climates

are similar in many respects, but they differ markedly in one respect--namely, in the length of the growing season.

In areas having the Short Summer Phase the average monthly temperature drops below freezing (32° F.) more than three months each year, but during the summer season at least four months have averages above 50° F. The average annual temperatures are somewhat lower than those in the Long Summer Phase. The absolute summer maximum may be nearly as high in the Short Summer Phase as in the Long Summer Phase, but in the former the hot spells are of much shorter duration. The minimum of winter is likely to be lower--occasionally records of -30° to -40° F. are not uncommon--and the cold spells last longer than in the Long Summer Phase. The major factors which cause the great seasonal extremes of temperature in this climate are distance from the ocean and the great difference in the length of day in summer and winter. The growing season is short; frosts may be expected late in the spring and early in the fall. In many localities not more than three or four months are free from killing frosts.

Two factors--namely, the cyclonic storms and monsoons-- are of outstanding importance in the wind regime of the Short Summer Phase of the Humid Continental climate. The chief factor in North America and Europe is the location of the region in the path of cyclones and anti-cyclones. In the northern interior of North America a fairly persistent area of high pressure develops

during the winter; this forces the storm paths to the southern part of the Short Summer region or even beyond it. Cold, northerly winds, which often last for days, are the result. In Asia the monsoons dominate the weather, while cyclonic wind movements play a minor role. The high pressure area of eastern Siberia causes strong out-blowing winds in winter, while in summer the pronounced low pressure area gives rise to persistent in-blowing winds.

On the average the annual precipitation is lower in the Short Summer Phase than in the Long Summer Phase. It ranges generally from 15 inches in the portions which lie farthest from the oceans to 25 inches in the more humid parts. The scantiness of the annual rainfall is offset by two favorable aspects--namely, its distribution and its efficiency in promoting plant growth. About 40 per cent of the precipitation falls during the short growing season, June to August inclusive. The efficiency of the rainfall is high because, owing to lower summer temperatures, the evaporation is not quite so great as farther south. That the snowfall is greatest nearest the ocean is shown in North America, where it increases eastward through the hay and dairy belt to near Montreal. In the heart of the North American continent the total snowfall is not great, but that which falls accumulates for long periods of time and forms a protective blanket for the soils. In Europe the regions near the Baltic have the heaviest snows. In Manchukuo, snowfall is

is light because of the prevalence of dry, out-blowing winds from the interior.

Thunder showers are common in the summer, although they are less frequent than in the Long Summer climate. Blizzards are characteristic aspects of the Short Summer winters, and they are more numerous than in the climate with short winters.

The gray-brownerths are the principal soils in the southern part of this climatic region where the relatively warm and humid conditions prevail.

In the northern section of the region in North America, extending from northern Minnesota eastward and including the adjacent part of Canada, and in a large part of the Russian area, leached gray soils, known as podzols, are predominant. The podzols are acid soils, deficient in mineral and in well-decayed organic matter. The surface layer is raw humus, made up of masses and partly decayed leaves and sticks, and may reach a thickness of a foot or more. This layer really lies on the surface.

Forests occur in the more humid portions. The forests are composed of the hardier deciduous trees in the southern part giving way to forests of pine, fir, hemlock, and spruce--coniferous trees which thrive where summers are short, warm, or hot, and rainy, and winters, long and cold. In general, the pines thrive on the drier soils of this region, and firs and spruces on the more humid soils. The tree crops yielded by the trees

in these forests include maple sugar and syrup, tanning materials, gums and resins, and some fruits, as persimmons and honey locusts. In the more climatically favored regions fruit orchards of apples, pears, plums, and cherries may be expected.

2. Marine West-Coast Climate.

The outstanding feature of the climate of this region is the prevailing westerlies and eastward-moving cyclonic storms moving from the ocean over the land throughout the year. The Marine West-Coast regions lie on the western edges of the continents with the result that the westerlies bring oceanic rather than continental conditions--the adjacent ocean prevents temperatures from becoming extreme and keeps the humidity high. Here the winters are mild and wet; summers are cool and damp. Frosts at sea level occur only a few days of each year. No season of the year is dry, but in general winter is the season of heaviest rainfall.

Mountains limit the regions having a well-defined marine climate to a coastal strip in North America, South America, Australia, and New Zealand. In North America this coastal strip extends from San Francisco to Alaska. In Chile it occurs from Puerto Montt to Cape Horn, again a coastal strip between the Andes and the Pacific. However, in Europe it goes farther inland and includes the whole of western Europe from Portugal northward to Norway. This type of climate exists on the southern coast of Victoria, Australia, and in Tasmania and New Zea-

land.

The dominant feature of this climate is the tempering influence of the westerly winds blowing from over the oceans. The difference between the average of the warmest and coldest months does not exceed 36° F., and for a few places it is less than half of this. The average winter and summer temperatures are, of course, higher in the lower latitudes than they are farther poleward where this climate prevails. In the higher latitudes where the marine climate occurs the mild winter temperatures are the outstanding features. Even far beyond the Arctic Circle in Norway the winters are so mild that the coastal waters remain unfrozen through the long winter months.

The weather is dominated entirely by numerous low pressure areas which move in from the sea. The passing of these "lows" cause constant shifts of wind direction and wind strength, resulting in highly variable weather. The winds from the westerly direction are by far the most frequent--from the southwest during the winter months, and from the west to northwest during the summer.

Besides causing mild winters and cool summers the westerlies bring oceanic moisture to the land. This gives the Marine West-Coast regions high humidity, cloudy skies, and heavy precipitation when the air is forced to rise on the westward side of mountains, or when it encounters land that is cool because the sum is low in winter. The mountain ranges running parallel

to the coast limit such precipitation to a narrow coastal margin in North America and Chile, and greatly diminish the area in Scandinavia, Tasmania, and New Zealand. Where there are no barriers, as in west central Europe, oceanic moisture is carried far inland.

All the west coasts of this climatic region are dominated by the oceanic type of rainfall. The rain does not fall in sudden heavy showers, but rainy weather may last for days, sometimes even for weeks. Rainy days are common, yet the total rainfall is not excessive (except where high mountains are near the coast) and the rain occurs in gentle drizzles rather than in thunderstorms. The maximum rainfall occurs during the autumn and winter months, with spring and early summer the season of least rainfall, when the winds from a relatively warm ocean blow over the land which has cooled to below ocean temperatures. The periodicity of rainfall, however, is not pronounced, and considerable rain falls in all months. The typically marine conditions of prevalent cloudiness and a winter rainfall maximum change rapidly, however, with distance from the ocean.

The high humidity causes the cold of winter to be sharp and piercing, even when the thermometer may reach well above the freezing point. In summer it often results in extremely muggy weather.

The agricultural soils of the areas which lie within this type of climate, particularly along the coasts of North Ameri-

ca, Chile, and Norway are limited to the valley lands. Their extent is relatively a small percentage of the total area involved. These lands which are wholly alluvial vary so much in different localities that broad generalizations have little significance. The soils are young, and where drainage is adequate and textures favorable to cultivation they are usually quite fertile.

The soil is varied partly because the parent materials have been widely distributed by glaciation. The predominant soils belong to an important group known as the gray-brown podzolic soils. These are the best of the world's forest soils. Because of the moist environment, they are usually at least moderately leached. However, they have an excellent physical culture and will readily absorb fertilizer.

The Marine West-Coast vegetation is or has been essentially heavy forest, but the climate here with its rainy, cloudy, cool weather and its continuously moist soils is not favorable for maturing and harvesting tree crops. As a result the variety of tree crops of this area are restricted to the hardier tree fruits and tanning materials from the native trees.[1] These are characteristic of Pacific North America rather than of any other Marine West-Coast area. In New Zealand the kauri pine furnish-

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[1] C. Langdon White and George T. Renner, Geography; An Introduction to Human Ecology, D. Appleton-Century Company, 1936, p. 229.

the valuable kauri gum of commerce.[2]

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[2] C. Langdon White and George T. Renner, Geography: An Introduction to Human Ecology, D. Appleton-Century Company, 1936, p. 229.

PART III

TREE CROPS CHARACTERISTIC OF THE DIFFERENT CLIMATIC REGIONS

CHAPTER VI

TREE CROPS OF THE TROPICAL RAINY CLIMATE

The regions under the influence of the Tropical Rainy climate are the richest in crop-yielding trees. Nature has generously willed to them not only every major type of tree crop, but numerous varieties of each type as well. Most of the standard exports from the tropical rainforests are tree crops which either are gathered directly from the forests by the natives or are raised on plantations.[1] Of the several hundred trees native to this climatic regime, many yield "crops" which have not as yet entered commerce. This is particularly true of the tropical fruits and nuts. Others are largely untested or unexplored from the standpoint of economic botany.[2] Therefore, the Tropical Rainy climatic regions have great crop possibilities in their trees.

The tree crops presented below are those which at present are of commercial utilization.

BEVERAGES

Cocoa and Chocolate. Cocoa and chocolate are a distinctly American contribution to the world's food resources, for it was

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[1] J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p. 243.

[2] Ibid., p. 243.

unknown in Europe until America was discovered.[3] It was first introduced into Spain and thence distributed through Europe. Cocoa and chocolate are prepared from seeds or beans of the fruits of the cacao or cocoa tree (Theobroma Cacao), a native of the tropical rainforests of the Amazon and Orinoco Valleys, and of southern Mexico.

After the introduction of cocoa to the peoples outside of the tropics, its popularity steadily increased so that the original regions of cultivation were insufficient to supply the demand, and new cacao areas have been developed in widely scattered portions within the tropics. Practically all the world's supply of cacao comes from three major regions: western Africa, eastern Brazil, and the Caribbean mainland and neighboring islands.[4] At present the countries of western Africa together lead in the production of cacao with about two-thirds of the world's total output. The better qualities, however, still come from the tropical Americas.

In western Africa the cacao plantations are mainly in the hands of natives who own and operate almost all the cacao lands and have complete control of the commodity until it reaches the

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[3] Clarence F. Jones, Economic Geography, Henry Holt and Company, 1935, p. 119.

[4] Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 171.

buyers. Only a minor per cent of the total plantations are directly under the control of Europeans.

The west African cacao production is located in the belt of equatorial rainforest which skirts the coastal lowlands of the Gulf of Guinea from Sierra Leone to beyond the mouth of the Congo River; the industry is of long standing in some of the islands of the Gulf of Guinea. On the mainland plantations extend from a point about fifteen miles from the seacoast, inland for several hundred miles. The principal center of production is the Gold Coast. Here more than a million acres are in cacao cultivation;[5] vastly greater areas suitable for cacao, but as yet uncultivated, represent possible future cacao lands in the same general vicinity. Nigeria ranks second in the cacao industry in western Africa, and third in the world. Cacao production on the Ivory Coast has been marked by a steady increase, resulting primarily from expansion by Europeans; though here there is plenty of good land available, there is a great paucity of labor. Other cacao farming areas are in Togoland, British and French Cameroons, Fernando Po, and São Thomé.

For a long time the Americas contributed all the world's cacao. Though no longer the leading area of world production, nevertheless, it is the region from which the superior grades of cacao still come. The leading area of production in the

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[5] Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 171.

Americas is the hilly, rainy, coastal strip of Bahia in eastern Brazil--a district about three hundred fifty miles in length, having 500,000 acres in cacao. Here a combination of physical, economic, and climatic factors favor the development of the cacao industry. The hot steamy lowlands of the Amazon were originally the center of Brazil's cacao industry; the industry in the Amazon, though favored by rather excellent physical conditions, has practically disappeared owing to the lack of care of old plantations, small and inefficient labor supply, meager transport vacilities, and excessive export taxes. Eastern Brazil is handicapped in its ability to compete with other areas having equally favorable physical conditions because the state and federal taxes amount to at least 20 per cent of the export price, and there is no encouragement given the industry by its government as is given by colonial governments of the west African colonies.

The cacao district of Ecuador lies in the alluvial lowlands (the lower slopes and floors of valleys) north of Guayaquil. For many years this country ranked as the leading producer and exporter of cacao. Physical conditions for cacao here were almost ideal, and the natives, long experienced in the industry, produced cacao of excellent quality. At one time Ecuador supplied 30 per cent of the world's export; now it contributes less than 3 per cent. This has resulted from the spread of two diseases: the Monilia disease which attacked the fruit broke

out in 1916, and in 1922 the witches'-broom disease, which attacked the trees and spread rapidly, forcing the abandonment of many plantations. The expense of combating these diseases plus the placement of heavy export duties amounting to two cents per pound became so prohibitive that Ecuador is in danger of losing its once great cacao industry.

Within the Caribbean region there are several small areas of production. The plantations here are located either on the lower slopes of deep valleys or on broad alluvial plains, with excellent physical conditions for cacao production. All the regions are near the sea and each district has numerous and excellent Negro workers who work cheaply and are skilled in preparing cacao for export. In Venezuela the majority of plantations are located in the narrow coastal strip east of Puerto Cabello, and in the region around the southern end of Lake Maracaibo. Colombia, Cuba, Porto Rico, Jamaica, Trinidad, San Domingo, Grenada, Dominican Republic, and Haiti are also producers of some importance.[6]

In Asia cacao-growing has been tried, and Ceylon and the Dutch East Indies together sometimes yield as much as the island of Grenada;[7] but on account of serious inroads of fungus diseases of the trees, cacao has not been a success in this re-

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[6] Bror E. Dahlgren, Cacao, Field Museum of Natural History, 1923, p. 12.

[7] Ibid., p. 12.

gion which otherwise is perfectly suitable, as to temperature, rainfall, and freedom of drought, for the cultivation of the tree.

Cacao is restricted by special climatic and environmental conditions to definite localities within the equatorial rainforests which meet rather rigid requirements. Cacao thrives best on the lower slopes and floors of valleys within the tropics because this crop cannot be grown at altitudes above 2500 feet.[8] A rich, deep, moist soil--not only well-watered but well-drained--is also highly important. A high annual rainfall of more than fifty inches with a somewhat whort, less rainy season--not a real dry season--favors the establishment of plantations on the edge of the Tropical Rainy regions.[9] The less rainy season such as is to be found in the transitional zone between the Tropical Rainy and the Tropical Monsoon favors the harvesting and drying of the "beans". High humidity, ranging between 80 per cent and 90 per cent, is essential.[10] Fogs and mists drifting up the valleys help keep the air humid.

Accompanying the high annual rainfall there must be high temperatures throughout the year, averaging at least 75° F., and

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[8] Albert F. Hill, Economic Botany, McGraw-Hill Book Co., Inc., 1937, p. 506.

[9] Clarence F. Jones, Economic Geography, Henry Holt and Company, 1935, p. 119

[10] Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1936, p. 406.

any temperature below 60° F. injures the tree.[11] Because of the sensitiveness of cacao to strong sunshine, natural or artificial shading is necessary so shade trees are often planted so they will tower above the cacao tree to protect them from the direct rays of the sun as well as to help keep the air humid by delaying the evaporation of moist air from the groves. Such combinations of heat and moisture are unhealthful for human beings, and it is therefore difficult to obtain adequate labor supplies.

Strong winds are harmful. Therefore, the necessity of having freedom from storms and strong prevailing winds limits cacao culture to the floors and lower slopes of protected valleys. Strong winds increase transpiration and cause the heavy pods to drop from the trees or dry up and produce poor "beans".[12] For this reason, many of the islands in the West Indies are unable to grow cacao, as they are exposed at times to high winds and storms.

Furthermore, the quality of cacao depends largely upon the skill of the workers and the care used by them in the gathering and curing of the beans. Therefore, cheap, skilled workers are necessary for low-cost production of a high quality product for

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11 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1936, p. 406.

12 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 171

world markets. In west Africa there is a difficult labor problem largely due to a scarcity of workers and to the necessity of importing casual laborers.[13] In the Caribbean islands and mainland the Negroes are numerous and are excellent workers of long experience, who work cheaply and with great skill in preparing the cacao for marketing.[14]

Profitable production of cacao further requires adequate means of cheap transportation. In west Africa those farms far from the villages require that the natives themselves must carry the cacao on their heads to the villages since work animals cannot live in this region of the tsetse fly.[15] From the village the cacao is taken by truck to railroad stations or to the coast. The importance of transportation here has resulted in millions of dollars being spent on roads and railroads to all parts of the cacao region, but the excessive rainfall makes the upkeep of roads costly and at times impossible. Then, when the coast is reached, further transportation difficulties arise, for nowhere does the shoreline possess a good natural harbor. Therefore, all cacao has to be hauled by longshoremen to vessels anchores a mile or more offshore.[16]

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[13] Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 173.

[14] Ibid., p. 175.

[15] Ibid., p. 173.

[16] Ibid., p. 174.

Eastern Brazil has the advantage of having rivers and railways available to bring cacao a short distance to ports where local steamers pick it up and deliver it to the chief export point, Bahia.[17] In the Caribbean region all the farms are near the sea and thus facilitate transportation.

The cacao tree is rather small, from fifteen to forty feet in height. The fruits--pods which look like large fat cucumbers--are borne on short stalks directly on the trunk and limbs of the cacao tree. Within each pod-like capsule is a number of "beans" (forty to sixty) imbedded in a shiny sweetish pulp. Such a manner of growth means that much hand labor is needed in harvesting, for the pods, one by one, must be cut off by the laborers with machetes. Because of this peculiar habit of the fruits growing in clusters on the trunk and larger limbs, their removal without injuty to the bark requires trained pickers.[18]

These trees begin to bear when four to five years of age, reach commercial bearing at twelve years and continue to the age of fifty. Trees produce flowers and fruit throughout the year so that several crops annually are possible. However, two principal crops are produced annually. Three-fourths of the entire crop matures during the somewhat drier season between Sep-

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17 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 174.

18 Otis W. Barrett, The Tropical Crops, The Macmillan Company, 1938, p. 88.

tember and February.[19]

After the pods have been removed from the trees, they are cut open and the "beans" are removed from the split pods, often by Negro women. The "beans" which are imbedded in the pulp are extracted and then piled into bins and allowed to "sweat" or ferment for four to six days, being turned by hand each day. Fermentation loosens the pulp, destroys the bitter taste, develops the flavor, and dries the "beans".[20] The "beans" are further dried either on open trays in the sun or in large kiln dryers. The quality of the cacao depends largely on the skill and care in preparing and curing the "beans". When the "beans" are dry, they are sacked and are ready to send to factories where the cacao is to be prepared for marketing.

Three to four hundred pounds of cacao "beans" are produced per plantation acre. Sometimes yields vary from seventy to more than sixteen hundred pounds per acre in west Africa.[21] Therefore, well-cared-for trees give a return of $15 to $20 per acre.

Cacao that enters world trade goes almost entirely to countries of western Europe--Great Britain, Germany, Netherlands, and Switzerland,--and North America, the United States

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19 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 172.

20 Charles C. Colby and Alice Foster, Economic Geography for Secondary Schools, Ginn and Company, 1931, p. 82.

21 Op. cit., p. 172.

taking nearly two-fifths of the world's total export. These two parts of the world consume 90 per cent of the world's cutput. The African supply goes directly to Europe, while the American supply is sent to the United States, especially from Brazil, Dominican Republic, Trinidad, and Ecuador.[22] In 1935 imports amounted to 606,310,791 pounds of cacao beans; 302,141 pounds of prepared chocolate; and 3,051,571 pounds of prepared cocoa.[23]

At the importing points the cacao "beans" are cleaned, ground, and roasted. These processes require skilled labor and expensive machinery, and therefore are carried on in regions of dense population and where sugar, milk, and other ingredients necessary for making cocoa and chocolate can be obtained quickly and cheaply. Chocolate is produced by adding some sugar to the finely ground "beans". Cocoa is made by eliminating most of the vegetable fat, the so-called cocoa-butter.

Cola (Kola). For the discussion of the cola (kola) tree and the use of its nuts for beverages see pages 185 to 189.

DRUGS AND MEDICINAL PRODUCTS

Cajeput. From the fresh leaves of Melaleuca Leucadendron,

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22 Clarence F. Jones, Economic Geography, Henry Holt and Company, 1935, p. 123.

23 Albert F. Hill, Economic Botany, McGraw-Hill Book Co., Inc., 1937, p. 509.

a small tree which grows in southeastern Asia, is obtained by distillation a pungent, aromatic, volatile oil called oil of cajeput. The cajeput tree, a native of the hotter parts of Australia, is from thirty to forty feet high with a crooked trunk, papery bark, and white wood--referring to the color of the bark. Kayuputi, the native name of the tree, means "white wood", hence the name cajeput.

The trees yielding the oil are found throughout the tropical rainforests of the East Indies, the Malay Peninsula, and north and northeast parts of Australia; but the greater portion of the oil comes from Celebes, and the two islands of Buru and Ceram in the Molucca group.[24] The bulk of cajeput oil is exported from the last two named islands.

Oil of cajeput is prepared from the fresh leaves which after gathering are macerated in water and then distilled after fermentation for a night. A hundred pounds of leaves yield slightly less than one pound of oil.

Cajeput is more extensively used in Europe than in the United States.[25] It is used as a stimulant, counterirritant, and antiseptic in the treatment of skin diseases, rheumatism, and bronchitis.

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[24] J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 106.

[25] Albert F. Hill, Economic Botany, McGraw-Hill Book Co., Inc., 1937, p. 267.

Chaulmoogra Oil. Leprosy, one of the most dreaded diseases of mankind, can now be cured. The cure is affected by the use of a fixed oil obtained from the seeds of the true chaulmoogra tree--Taraktogenos kurzii.[26] This large tree is native to the edge of the tropical rainforests and jungles of southeastern Asia.

The true chaulmoogra-oil tree is now found in pure stands in the dense tropical forests of northern Burma--in the upper Chindwin district, near Kyokta.[27] Only scattered individuals have been found in Assam.[28] These trees are also existent in the tropical forests of the East Indies.

Taraktogenos kurzii do not bear fruits until the eighth year after planting;[29] even then they are irregular bearers, producing a good crop once in three years. This is true of the tree under forest conditions, while trees standing free in the sunlight bear regular heavy crops.[30] This would indicate the value of plantation culture. The velvety fruits which are about equal in size to a small orange ripen in July. Within the hard rind is a sweetish pulp, closely packed with several large

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26 Joseph F. Rock, Hunting the Chaulmoogra Tree, National Geographic Magazine, XLI (1922), p. 243.

27 Ibid., p. 263.

28 Ibid., p. 275.

29 Ibid., p. 243.

30 Donald C. Peattie, Cargoes and Harvests, D. Appleton and Company, 1926, p. 265.

seeds which contain a fatty oil. Natives come only once in three years into the forests to gather the seeds, as in the other seasons there are not enough seeds to make collection profitable. Then only about half the seeds of the fat season can be secured, because of the fondness of monkeys, boars, and bears for the chaulmoogra fruits, and because the collectors do not take the fruits from the trees when ripe, but wait till they drop, a much less troublesome way to collect them.[31] The monkeys are fond of the fruit flesh and attack the fruits while they are still on the trees, dropping the seeds to the ground. Porcupines then devour the seeds from the ground. Thus in all probability about fifty per cent of the crop is lost.[32]

The oil is expressed from the seeds--a brownish-yellow liquid or soft solid, and is known commercially as chaulmoogra oil. The presence of certain acids in this highly valuable oil were found by experiments at the University of Hawaii to be the most successful in the treatment of leprosy.

The ethyl esters for treatment of lepers is manufactured in Hawaii. These leprosy specifics are now manufactured by several firms, but not in quantities large enough to supply the world. This can only be done by growing the trees as a plantation crop.

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31 Donald C. Peattie, Cargoes and Harvests, D. Appleton and Company, 1926, p. 265

32 Ibid., p. 265

The desirablilty of growing chaulmoogra under plantation conditions becomes obvious when one considers the unsatisfactory conditions of the wild crop. Not only are the natives wasteful in their harvesting, but monkeys, bears, and porcupines are getting half the world's supply! The trees under forest conditions fruit shyly and irregularly, and are inaccessible to satisfactory exploitation. The seeds on their long journey from forest to bazaar get rancid and lose their properties, and the price is higher than it will be when chaulmoogra plantations come into bearing. The one great drawback to plantation development is that it takes the trees eight years to come into bearing. In our Pacific island possessions--Hawaii and the Philippines--plantations have been established.[33]

Guaiacum. Guaiacum or gum guaiac is a hard resin used as a stimulant and laxative, in the treatment of rheumatism and gout, and as a chemical indicator because of its sensitiveness to oxygen. This hard resin is obtained from the stems of the lignum vitae trees (Guaiacum officinale, G. arboreum, G. sanctum), evergreens native to the West Indies, and northern South America. Guaiacum of commerce is furnished from trees growing in the tropical rainforests of the West Indian islands (Haiti, Cuba, Santo Domingo, and Jamaica),[34] the Bahamas, Key West in

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33 Op. cit., p. 270

34 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 14.

Florida, southern Mexico, Central America,[35] and the valley of the Magdalena in Colombia up to an altitude of 2625 feet.[36]

The resin may be obtained in several ways: 1)by natural exudation from the living trees or by incision made in the stem to give large irregular masses or "tears" of various sizes and of brownish or greenish-brown in color; 2) by heating billets of heartwood, about three feet in length, bored to permit the outflow of resin; or 3) by boiling chips, raspings, or shavings in water.

Much of the lignum vitae is exported in large logs or blocks, generally divested of the bark and the resin is extracted at the importing centers, being exported in such form from the West Indies.[37]

Quassia. Quassia-wood, or Quassia-chips which furnishes a drug is obtained from two different tropical trees: Picraena excelsa, a tall tropical tree of Jamaica and other West Indian islands, as Antigua and St. Vincent, furnishes Jamaican quassia; Quassia amara, a native of tropical America, produces the commercial Surinam quassia in Panama, Venezuela, Guiana, and

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35 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 53.

36 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 125.

37 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 14.

northern Brazil as well as in the West Indies.[38]

Picraena excelsa is inferior to Quassia amara; but this inferiority is compensated by the greater facility with which any requisite supply is obtained. It is the wood of this tree which is more commonly sold as Quassia-wood, or Quassia-chips. Surinam quassia, formerly the true quassia, is employed in France and Germany, while Jamaica quassia finds its demand in North America. The United States imported 625,151 pounds of crude quassia in 1935.[39]

Quassia is shipped in the form of billets or chips; and the drug is prepared by making an effusion of chips or shavings. The drug has a very bitter taste and is used as a tonic, in the treatment of dyspepsia and malaria. It also serves as an insecticide.

Quinine. One of the most important medicinal drugs known is quinine, and it has been a great boon to mankind in its treatment of malaria. The chief source of quinine is the bark of several species of the genus Cinchona (calisaya and cordifolia), popularly called Peruvian bark.

The principal original habitat of the cinchona tree was the eastern slopes of the Andes Mountains in the northwestern part of South America (from between 10° N. latitude to 19° S.

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[38] Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 265.

[39] Ibid., p. 278.

latitude) at an elevation of 3000 to 10,000 feet.[40] This belt extending from Colombia to Bolivia especially included the Yungas of Bolivia and the Montañas of Peru,[41] (hence the denomination "Peruvian bark"). Here where the cinchona tree grew plentiful in a wild state the mean temperature of 54° F. existed.

Until 1880 the South American forests, primarily those of Colombia, Ecuador, and Bolivia, produced most of the world's quinine. Here the industry has had many tragedies ranging from the destruction of tree to the mistreatment of the natives. The supply seemed inexhaustible, but rapidly diminished under wasteful methods of collection. As much as 25,000 trees were felled annually in one district alone.[42] The trees were cut down in order to strip off the bark, which was then dried in the open or over fires in huts. Another problem in this region was the inaccessibility of the forests because of their location--the Andes a barrier of the west and the Amazon forests a barrier on the east.

It soon became evident that attempts at cultivation must be made if this indispensable drug was to be available for fu-

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40 Samuel H. Cross, Quinine Production and Marketing, Trade Information Bulletin No. 273, Bureau of Foreign and Domestic Commerce, 1924, p. 1.

41 Clarence F. Jones, South America, Henry Holt and Co., 1930, p. 56.

42 Donald C. Peattie, Cargoes and Harvests, D. Appleton and Company, 1926, p. 38.

ture generations. Both the Dutch and English sent collectors to South America, but the Andean natives guarded the remnants of the cinchona forests most zealously. In spite of dangers and hardships, however, a few seedlings and seeds were finally smuggled out of the country and became the basis of the cinchona plantations of today. The French made the first attempt to grow cinchona for medicinal purposes on a small plantation in Algeria, but probably because of the lack of waters the trees all died. It was left for the Dutch to successfully start cinchona plantations on Java where the high, rainy mountain slopes of the islands, warm but not hot, were similar in physical respects to the Andean highlands where the cinchona was native.[43]

At present scientifically managed plantations supply the principal source of the world's quinine. Until the outbreak of World War II the mountain slopes of western Java furnished 99 per cent of the world's supply on Dutch estates.[44] Here over 40,000 acres were devoted to the industry. In nearby Sumatra the Dutch had over 4000 acres.[45] The balance came from plantations financed mostly by British manufacturers in British India where there are large government plantations at Darjee-

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[43] Op. cit., p. 39.

[44] Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography (rev. ed.), Prentice-Hall, Inc., 1943, p. 441.

[45] J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 116.

ling in the Northwest, and in the Nilgiri Hills in the South.[46] Other cinchona plantations exist in Ceylon and Madagascar. Small amounts of cinchona still reach the principal markets from Peru, Colombia, Ecuador, and Bolivia. Competition with quinine produced in the East Indies which is better and lower-priced has discouraged South American production in the years prior to World War II.

Cinchona trees require an annual rainfall of 80 to 130 inches, well-distributed throughout the year--a rainfall characteristic of the Tropical Rainy climate.[47] Temperatures ranging from tropical to subtropical through the year are also necessary, ranging between 56° F. to 86° F. without night frosts.[48] The tree grows best on young soil on mildly sloping ground, porous, but well-drained.[49] Therefore, the well-drained terraced mountain slopes up to 5000 feet or higher are sought in selection of cinchona plantation sites. The rich volcanic soil of the mountainous parts of the East Indies has been found to be most suitable.[50] Accessibility to the main markets and

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46 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 116.

47 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 65.

48 Samuel H. Cross, Quinine Production and Marketing, Trade Information Bulletin No. 273, Bureau of Foreign and Domestic Commerce, 1924, p. 4.

49 Ibid,, p. 4.

50 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 116.

trade routes also is important; the cinchona forests of the Andes are inaccessible from the west because of the high Andes, and on the east the dense Amazon rainforest stretches for a great distance making the region remote from the Atlantic. This causes difficulties in transportation to ports on the eastern and western coasts of South America. If ever solved, someday this may become a great plantation region, provided there is still a demand for quinine. Cheap, abundant, skilled workers are needed for producing quinine for market at low cost; the East Indian workers are better than the South American Indians. In South America the cinchona-producing trees are in a region of sparse population which are not well-adapted to steady work.

Cinchona plantations are set out with trees raised from seeds. When the trees are six to seven years old, they produce a good harvest; trees may be stripped three years after planting, but they do not yield much bark. Though the lifetime of a cinchona tree is fifty years at maximum on good soil, the plantations are renewed every twenty years for best results.[51] An acre produces about 600 pounds of dry bark each year on the great scientific plantations. This is an average of two pounds per tree.

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[51] Samuel H. Cross, Quinine Production and Marketing, Trade Information Bulletin No. 273, Bureau of Foreign and Domestic Commerce, 1924, p. 7.

The collection of bark is by one of three methods;[52] the older method--generally followed in South America-- is to uproot or fell the tree and strip off the bark which is then dried in the sun or over fires, the bark being taken from both the stem and root--the latter part is especially rich in alkaloids; in India the bark is removed in alternate longitudinal strips, and the exposed surface is then covered with wet moss to promote the growth of a new layer of bark--the second bark being found to be richer in quinine than the natural bark of the tree--but this practice has been found to encourage the growth of fungus and insects beneath the wet moss, and so is being discontinued;[53] the third method is by slicing off with a tool only the outer layer of bark in alternate strips, thus obviating the use of wet moss.

Quinine's major use is in the preparation of medicine for use in the treatment of tropical fevers, especially malaria; but in addition it is valuable as a tonic and antiseptic. Its greatest demand is from Europeans in India, the East Indies, Africa, and other tropical and subtropical regions that are under European influence. The southern part of the United States is also a market for quinine, purchasing (in 1935) 1,618,252

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52 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 117-118.

53 Samuel H. Cross, Quinine Production and Marketing, Trade Information Bulletin No. 273, Bureau of Foreign and Domestic Commerce, 1924, p. 6-7.

pounds of bark.[54] It is estimated that no less than six million pounds of dry bark can be furnished annually by cinchona plantations during peace times; but the demand for quinine has diminished because of synthetic drugs which have been recently placed on the markets.

DYES AND PIGMENTS

Annatto or Arnotto. An important yellow coloring material comes from the seeds of the fruit of Bixa orellana, a small evergreen tree native of the tropical rainforests of Central America, but cultivated at present in many other tropical countries having similar physical and climatic conditions--principally Central America, the West Indies, Brazil, the Guianas, India, and Ceylon.[55]

Bixa orellana is one of the most satisfactory trees as far as growth and behavior are concerned. This tree begins to bear fruit in the second year, and averages 300 to 600 pounds to the tree.[56]

The reddish-brown, heart-shaped fruits contain from thirty to fifty seeds, each surrounded by a red fleshy seed-coat. This pulpy layer about the seed yields a bright yellow dye which forms the annatto of commerce. The dried seeds with pulp

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[54] Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 278.

[55] J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 323.

[56] Ibid., p. 323.

adhering are exported; or a red or orange liquor or putty-like paste is made from the aril.[57] For the latter the seeds with the seed-coats are separated from the husks and allowed to macerate in water until the mass ferments; then it is strained through a sieve and evaporated down to the consistency of putty, and may then be dried in the sun.[58] Sometimes the aril is merely scraped off and made into a paste for shipment. The best kinds are Ceylon and Cayenne annatto, the latter from French Guiana is exported in the form of bright yellow cakes of two to three pounds each, and wrapped in banana leaves.

Because annatto is nearly tasteless, it is well-adapted for coloring butter, cheese, and other foodstuffs. Other uses are for coloring paints, varnishes, lacquer, soap, and woolen and calico goods. The United States finds commercial use for this dye material, importing as much as 837,919 pounds in a single normal year (1935).[59]

Barwood and Camwood. Baphia nitida, a West African tree, is the source of these two dyewoods[60] which furnish a brilliant red color used in the United States chiefly for calico printing, being the only dyestuff used for dyeing cotton a mock tur-

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57 Charles R. Toothaker, Commercial Raw Materials, Ginn and Company, 1927, p. 184.

58 Op. cit., p. 323.

59 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 152

60 Ibid., p. 146.

key-red. This tree grows in various parts of the tropical rainforest regions of West Africa, especially Sierra Leone.[61]

Fustic. Fustic--also known by such trade names as old fustic, fustic mulberry, yellow wood, Cuba wood, and mora--is the principal source of natural yellow dyes. It has been in common use for a long time, especially in dyeing woolen goods a yellow brown or olive color. Next to logwood it is the most important dyewood imported into the United States.[62]

The dye, called true fustic or old fustic, is obtained from the heartwood of Chlorophora tinctoria,[63] a tree of the dense tropical rainforests of the East and West Indies, Mexico, Central and South America. Mexico and Central America are at present the chief sources of this dyewood.[64] The fustic tree reaches a size of only about two feet in diameter and about fifty feet in height in its native habitat. The tree is always trimmed off before shipment to save freight as it does not contain sufficient coloring matter. Fustic is usually imported in the form of logs from two to four feet long and three to

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61 Raphael Zon and William N. Sparhawk, Forest Resources of the World, McGraw-Hill Book Co., Inc., 1923, p. 987.

62 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 418.

63 Albert F. Hill, Economic Botany, McGraw-Hill Book Co., Inc., 1937, p. 145.

64 Raphael Zon and William N. Sparhawk, Forest Resources of the World, McGraw-Hill Book Co., Inc., 1923, p. 918.

twelve inches in diameter. Sometimes fustic is exported in the form of blocks, sticks, chips, powder, liquid extract, or paste.

Imports of old fustic (raw materials) into this country in 1935 was 4,386,008 pounds.[65] Old fustic wood in one hundred weight blocks come from Nicaragua, Cuba, Jamaica, and to some extent from Venezuela and Mexico.[66]

Gamboge. A yellow dye known as gamboge is obtained from a yellow gum-resin which is exuded from a tree, Garcinia Hanburyi,[67] G. cambogia,[68] and other species. These trees grow in the East Indies, Ceylon, Cambodia, and Siam, the latter country exporting most of the resin of commerce.[69]

The bark is notched and the yellow viscous juice which oozes out dries on exposure. Usually the exudation is collected in hollow bamboos and allowed to harden into cylinders. Consequently, gamboge is exported in the form of solid rolls, bearing the striated impressions of the bamboos on the surface.

The bright yellow dye is much used by artists as a water-coloring pigment, for staining wood, coating brasswork, and to

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65 Albert F. Hill, Economic Botany, McGraw-Hill Book Co., Inc., 1937, p. 152.

66 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons., Ltd., 1929, p. 323.

67 Op. cit., p. 150.

68 Op. cit., p. 324.

69 Ibid., p. 324.

give a gold tinge to varnishes used for lacquer.

Logwood or Campeche. Logwood or Campeche is one of the oldest and most important dyestuffs. It is now used more than all other woods together for coloring purposes, constituting about 75 per cent of all dye-extract materials imported into this country.[70] The dye is obtained from the heartwood of Haematoxylon campechianum, a small thorny leguminous tree with peculiarly corrugated and clustered trunks. Logwood is a native of Central America in the dense tropical forests on the margins between the Tropical Rainy and Monsoon Tropical climates.[71] It has now been introduced throughout the tropics.

The commercial sources of logwood are Haiti and Jamaica in the West Indies, Yucatan and the Bay of Campeachy region in Mexico, Honduras and British Honduras in Central America, and Brazil in South America. It has been successfully introduced and grown in India.[72]

Haematoxylon campechianum can be propagated from seed and is now being cultivated to a considerable extent. When ten to twelve years of age, the trees are cut; and the bark and sapwood are removed.

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[70] Nelson C. Brown, Timber Products and Industries, John Wiley and Sons, Inc., 1937, p. 180.

[71] J. Russell Smith and M. Ogden Phillips, North America, Harcourt, Brace and Company, 1940, p. 908.

[72] Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 416.

Either the logs or extract are exported. As much as 40,000 tons of the purplish-red extract have been made annually, and is known as haematoxylin. Logwood is exported from Brazil and the West Indies in short logs (5 to 10 inches in diameter) from which the bark and sapwood have been removed, but as it appears in the markets it consists of small dark purplish billets of wood, about one-fourth of an inch long and somewhat less wide and thick.[73]

Logwood extract is made in the West Indies as well as in America and Europe, and the commercial preparation is in both powder and liquid form. The United States obtains its supply of raw material and extract from the West Indies and Central America; imports (1935) of the former soared to 25,500,160 pounds, while that of the latter was only 155,886 pounds.[74]

Logwood is extensively used for dyeing cotton and woolen goods. It is chiefly used with iron salts to give a black color, and it is considered superior to the aniline blacks. This black is the best and most lasting obtainable. Therefore, logwood is also used in making some inks. Haematin, a dye or stain derived from logwood, finds its greatest use in histological work by microscopists; no satisfactory synthetic substance

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[73] Wilfred W. Robbins and Francis Ramaley, Plants Useful to Man, P. Blakiston's Son and Co., Inc., 1937, p. 407.

[74] Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 152.

has been developed for haematin.[75]

Sappanwood and Brazilwood. The heartwood of Caesalpinia sappan, now known as sappanwood, was the first red dyewood discovered.[76] Caesalpinia sappan is a native of India and Malaya, and is now cultivated there and elsewhere in the Asiatic tropical rainforests of Burma, Siam, China, Japan, Ceylon, and the East Indies.[77] This red dyewood was introduced into Europe during the Middle Ages, and was called "bresel wood".

Then when the Portuguese discovered along the rainy east coast of South America, from Cape Sao Roque to the south of Santos, a dyewood similar to sappanwood which in Europe was called "bresel wood", they naturally gave to it the same name "bresel", and this name later was also applied to the country in which the tree was found, i.e. Brazil.[78] The New World brazilwoods include a variety of woods of the genus Caesalpinia, which appear on the market under a great confusion of names.

Pernambuco-wood from C. crista is recognized as the most valuable of these woods, and grows largely in Brazil, Mexico,

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[75] Op. cit., p. 407.

[76] Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 146.

[77] Raphael Zon and William N. Sparhawk, Forest Resources of the World, McGraw-Hill Book Company, Inc., 1923, p. 978.

[78] Op. cit., p. 146.

and Jamaica.[79]

Brazil-wood from C. braziliensis comes from tropical Central and South America, from Brazil, and from throughout the West Indies and the Bahamas.[80]

Lima-wood or Nicaragua-wood from C. bijuga comes from the Central American countries and the northern countries of South America.[81]

The coloring matter is in the heartwood of all Caesalpinia trees, and is extracted with boiling water. To some extent the bark can be used as a source of dye. The red dye is used for cotton and woolen cloth, and for red ink.

Sappanwood is exported largely to European countries; the brazilwoods are imported mainly by the United States, imports of raw material of brazilwoods in 1935 equalling 584,581 pounds.[82]

FIBERS

Coir. Coconut fiber, known commercially as coir, is the only prominent fiber which is obtained from fruits--from the thick outer husk of the unripened fruit of the coconut palm

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79 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 322.

80 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 417.

81 Ibid., p. 417.

82 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 152.

Cocos nucifera). Coir is a rather short, coarse, rough fiber, four to ten inches long, and of a brownish color.

Though the coconut palm grows in abundance along the sandy shores of nearly all tropical countries, and occasionally in inland localities, the production of the coir of commerce is confined almost exclusively to the Laccadive Islands and adjacent shores of southern India, Ceylon, and in south China.[83] The chief center of coir production is Ceylon.

The green coconuts are soaked in salt water for several months to loosen the fibers. They are then beaten to separate the fibers, which are then washed and dried. One thousand coconuts will yield 165 pounds of coir fiber.[84]

Uses of coir are varied. In tropical Asia and the South Seas it is the source of sennit braid, which is used for hawsers, cables, and small cordage. Coconut fibers are very light and elastic, and exceedingly resistant to water. Other uses include doormats, floor coverings, coarse textiles, upholstery, stuffing for bearings of railroad cars, and as substitute for oakum.

Coir is listed among our imports of raw fibers, amounting to 848 tons in 1935.[85]

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83 Liberty H. Bailey, Cyclopedia of American Agriculture Vol. II, The Macmillan Company, 1907, p. 292.

84 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p.368.

85 Ibid., p. 62.

Kapok. Without question kapok is the outstanding silk cotton and the most valuable of all the stuffing materials.[86] It has been used as a filling for mattresses for so long that it has come to be called the "mattress-growing" tree. The botanist refers to it as "Ceiba petranda". To those who man our planes and boats over the waters of the world it is the "life saving" tree, for its use in various kinds of life-saving equipment.

Kapok is the short-stapled cotton-like floss or fibers of the seed pods of the kapok tree--Ceiba petranda--an erect, quick-growing tree, reaching heights of fifty to one-hundred feet. The fibers of the kapok--whitish, yellowish, or brownish in color--spring from the inner wall of the pod, and consist of cylindrical hairs from one-half to one and one-half inches long.

The Kapok tree is native to tropical regions in the marginal portions of the Tropical Rainy climate, close to the regions of Tropical Monsoon climate. At present the principal areas of commercial production are within this same climatic type. Kapok is common all through the Philippine Islands, India, Ceylon, Malaya, and the Netherlands East Indies, particularly on the islands of Java, Sumatra, and Madura.[87] Commer-

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[86] Mary Fanti, The Mattress-Growing Tree--Kapok, The Journal of Geography, XLII (1943), p. 96.

[87] Ibid., p. 96.

cial production of kapok is not limited to Asia alone, for it is produced in the drier parts of the Maracaibo Lowland of Venezuela,[88] in the Pacific margin of Ecuador and Colombia, from the Gulf of Guayaquil northward through the Atrato Valley to the Isthmus of Panama,[89] in the Central Uplands of Brazil in the state of Minas Geraes,[90] in Mexico, and in the West Indies.[91] In Australia and some of the South Sea Islands, the kapok tree is grown, not for its fibers, but as windbreaks and shade for smaller trees. However, the most important area of recent commercial kapok production is Java.[92]

The kapok tree thrives best on the combination of tropical climate and light, porous, well-watered volcanic soils such as are found in Java. The tree does not require excessive precipitation, needing no more than seventy-two inches annually; nor does it want the rain distributed evenly throughout the growing season.[93] A somewhat drier season with bright sunshine is desirable, especially during the harvesting and drying of the kapok fibers. Such pronounced differences between wet and

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88 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 620.

89 Ibid., p. 548.

90 Ibid., p. 421.

91 Mary Fanti, The Mattress-Growing Tree--Kapok, Journal of Geography, XLII (1943), p. 97.

92 Ibid., p. 97.

93 Ibid., p. 98.

dry monsoon regions all through the southeastern portion of Asia. Not only can the tree stand long droughts, but it welcomes them during the interval from the first appearance of the flowers until the harvesting of the pods, a period of five months, from January or February to June or July.

The tree thrives best at altitudes of less than fifteen hundred feet, but that varies with the latitude. Site, too, is important. Overexposed locations where wind-damage during monsoons is imminent, dark and too-confined spots are unfavorable. Though the tree thrives on rich volcanic soils as well as on poor sandy loams, it requires that the soil be well-drained.

Where kapok trees grow wild, the gathering of the pods represents a forest-gathering industry. Elsewhere, kapok is grown on plantations, both in small patches or large estates. The small estates are cultivated by small farmers who grow the trees in patches or in rows around their fields or dwellings. Small farmers produce 90 per cent of the output of kapok.[94] On the other hand the larger estates may have nearly 6000 acres in pure kapok planting and nearly 20,000 acres in mixed plantings where the kapok trees line the fields of coffee and cacao or shade those trees between rows.[95]

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[94] Clarence F. Jones, Economic Geography, The Macmillan Com- 1941, p. 240.

[95] Ibid., p. 241.

Kapok is very readily propagated either from seed or by five foot stake cuttings which are planted in small patches or on large estates in pure stands about eighteen feet apart. When planted as a secondary crop or as prospective shade trees for young coffee or cacao trees, then they are set out forty feet apart. Kapok becomes a secondary crop where because the soil is rich such crops as Manila hemp, sugar, coconuts, coffee or cacao are the primary crops because they are more remunerative.

Although the first pods appear in about three to four years, commercial bearing does not begin until the sixth or seventh year,[96] the yield increasing until the limit is reached at about the fiftieth year. A mature tree yields from six hundred to one thousand pods, netting about six to ten pounds of cleaned floss.[97] Most trees, however, average two to four pounds of kapok annually. On the average, five hundred pounds of floss per acre is considered a satisfactory annual crop.[98]

The harvesting season coincides with the dry season. When the pods--resembling misshapen cucumbers about five inches long and two inches thick--turn from green to brown and become deeply wrinkled and burst, they are ready for harvesting. The harvesting season lasts three months, several pickings being

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96 Op. cit., p. 241.

97 Mary Fanti, The Mattress-Growing Tree--Kapok, Journal of Geography, XLII (1943), p. 98.

98 Ibid., p. 98.

necessary because not all the pods open simultaneously. Native gatherers detach the pods by means of long bamboo poles with hooks or knives fastened to one end. Pickers must use extreme care and pick only the properly ripened pods, for fibers of the unripe pods can lower the quality of a bulk of fiber. Experienced hands can clean a large-sized tree in about fifteen minutes.

The harvested pods are sorted by women who throw out the unripe or unsound fruits. Then in factories women break open the pods and remove the mass of floss which is then sent to drying compounds--level, open places with clay floors, covered with netting to prevent the fluffy kapok from being blown away by the wind. Here it is thoroughly dried in the sun by being repeatedly turned over by natives using bamboo poles. After a thorough aeration the billowy mass is gathered again and put into a seeding machine for ginning. In some regions the fibers are removed from the seeds by hand, chiefly by women and children. After ginning, the fibers are compressed into bales, wrapped in gunny cloth or matting and bound.

Because of its extreme lightness and resiliency to matting, kapok is an ideal stuffing material for mattresses, pillows, cushions, and upholstery. The fibers have a very low specific gravity and are impervious to water because each fiber is covered on the outside with a waxy substance. Kapok is five times as buoyant as cork and cannot be saturated, even after long im-

mersion in sea water. In water kapok can support twenty to thirty-five times its own weight. This buoyant quality of kapok makes it very valuable as a filling for life preservers, life-jackets, life-cushions, and similar life-saving equipment. Its use in buoys supporting flares for guiding night fliers, and in floats (pontoons) for portable military bridges illustrates present war time uses based on the buoyancy of kapok. The fiber of kapok has a great opacity to sound and vibration as well as temperature and this makes it a wonder fiber where sound proofing and thermal insulation are necessary.

The seeds, a valuable by-product, increases the revenue to the kapok grower. An acre of 132 trees yields about one thousand pounds of seeds, 23 per cent to 45 per cent of whose weight is oil. It is yellow-colored, non-drying, practically tasteless and odorless, and closely resembles refined cotton-seed oil. This oil can be put to all the uses to which cotton-seed oil is suited. The higher grades are used for oleomargarine; the lower, in soap-making.[99] The press-cake resulting after the oil is removed is used as cattle feed.

Kapok fibers and oil find their best markets chiefly in the United States and Europe. In 1935 the United States imported 12,385 tons of kapok, chiefly from Java, the Philippine Islands, and Ceylon, though some of the supply came from Mexico.

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[99] Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 218.

During the same year 12,656,625 pounds of kapok oil seeds were imported.[100]

Kapok will not likely become a strong commercial competitor of any other fiber[101] because the smooth slippery surface and absence of an axial twist have prevented it from being carded and spun.

Piassavas. The leaf stalks or leaf sheaths of certain species of palms growing in tropical America and Africa yield the important vegetable fibers known commercially as piassava, piassaba, or bass. These leaf stalks or leaf sheaths yield a stiff, coarse, brown or black fiber used in making brushes, brooms, and whisks. The two most important commercial piassavas are of South American origin--Para and Bahia piassava. West Africa supplies another variety from the wine palm. A small amount of Madagascar piassava from the "Vonitra" palm is exported from Madagascar. Palmyra fiber, Gemutu fiber, and kittul (kitool) fiber are classed as piassava in trade but are of less importance than those mentioned above. In all 23,367 tons of palm leaf fibers entered the United States' ports in 1935.[102]

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100 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 61.

101 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 241.

102 Op. cit., p. 61.

Para Piassava. These fibers are produced on the margins of the leaf petioles of Leopoldinia piassaba. This Brazilian palm grows only in the swampy regions of the valley of Rio Negro, a northern tributary of the Amazon.[103] Its exploitation is limited by reason of the comparative inaccessibility of the region where it grows, and the fact that energies of the Amazon Valley are almost entirely absorbed by the rubber industry. Therefore, only a small amount is collected yearly.[104]

The stem of the Leopoldinia piassaba is thickly covered with masses of coarse fiber, hanging from the leaf bases.[105] These fibers, often five feet long, are collected by natives and roughly heckled by drawing them through sharpened sticks fixed in the ground. The fiber when straightened and cleaned is pressed into bales for export.

The black, flattened fibers are flexible and strong, their qualities rendering them suitable for making brushes for grooming horses.

Bahia Piassava. Attalea funifera, another Brazilian palm, though growing in great abundance in the "restinga" of southern Bahia and northern Espirito Santo, is chiefly found in the dis-

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103 Joseph E. Agan, Brazilian Fibers, Bulletin of the Pan American Union, L (1920), p. 396.

104 Ibid., p. 396.

105 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 47.

tricts of Santa Cruz, Belmonte, and Porto Seguro in Bahia, where the palms form veritable forests. Another important source of supply is the valley of the Rio Preto, a tributary of the Rio São Francisco in northern Bahia.[106]

The "restinga" is the land formerly part of the bottom of the sea, and its soil is extremely poor and sandy. Nevertheless the piassava palm flourishes throughout its extent. One fiber company claims six million trees on its property in this area north of Bahia city.[107]

No culture of piassava is necessary or practiced; it is simply a wealth of the wilderness. Twice yearly the thick covering of fibers wound spirally about the trunk of the palm is removed by means of combs of the most primitive sort--generally made from pieces of wood fitted with nails for teeth. Sometimes the fibers are removed with an ax.

A single tree yields five to ten pounds of fiber at a gathering, and the yield can be increased by almost one-half if the tree is cut down. This is a destructive practice and is common on state lands.

The gathered mass of bark and fiber is soaked in water for some days until the pulp and useless tissues have rolled out.[108]

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106 Joseph E. Agan, Brazilian Fibers, Bulletin of the Pan American Union, L (1920). p. 396.

107 Ibid., p. 396.

108 Ibid., p. 398.

Then it is allowed to dry for some time under cover, is cleaned, combed off, and assorted as to length and grade.

The longer fibers are used in making ropes and twine; the heavier, coarser kinds are cut into short strips for brooms, road-sweeping machines, brushes, sandals, and hats.[109]

The United States and Europe have bought increasing amounts yearly as new applications were found for this fiber.[110]

West African Piassava. This piassava is rapidly becoming an important commercial product.[111] The fiber is obtained from Raphia vinifera (wine palm) which is exceedingly abundant along the hundreds of brackish tidal bayous and creeks of Liberia, Sierra Leone, and the Gold Coast as well as other countries of the west coast of Africa.[112] Millions of these palms exist in that general vicinity.

Each palm has thirty to forty foot leaf stalks which are retted until the long, wiry, fibro-vascular bundles can be beaten loose from the softer tissue of the midrib. This is back-breaking work; in addition there is danger in standing in the black mud, knee-deep, rain or shine, mosquitoes and Glossina pestering, and flail out this piassava. Because of this it will

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109 Op. cit., p. 398.

110 Ibid., p. 398.

111 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 47.

112 Ibid., p. 47.

probably never be cultivated.[113] After the fibers are dried in the sun, they are sorted and packed for export. The long, brownish-red fibers (three to fifteen feet) resemble whalebone, being stiff and wiry, and is used for making brooms, brushes, and mats.

Madagascar Piassava. The "Vonitra" palm, Dictyosperma fibrosum, a native of Madagascar, yields a brown fiber measuring one and one-half to two feet in length, a fiber finer and more flexible than Para or Bahia piassava.[114]

Palmyra Fiber. Leaf sheaths of the Palmyra palm, Borassus flabellifer, a native of Africa and Asia, yields a stiff, wiry fiber used as a substitute for piassava. The tree is extensively cultivated in India, the East Indies, and Ceylon for its fibers as well as for many other uses.[115] The fibers are made up into rope, twine, paper, and machine brushes.[116]

Gemutu Fiber. The sago palm, Arengo saccharifera, cultivated in the Moluccas and other parts of the East Indies produce Gemutu fibers. These are black, stiff, very durable, resem-

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113 Otis W. Barrett, The Tropical Crops, The Macmillan Company, 1938, p. 340.

114 Op. cit., p. 47.

115 Ibid., p. 48.

116 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 46.

bling horsehair, and are used for brushes and also for rope.[117]

Kittul (Kitool) Fiber. Jaggery or toddy palm (Caryota urens), a tall palm common in parts of India[118]--Malabar, Bengal, Assam--Ceylon, the Malay Peninsula,[119] and the East Indies.

The fiber comes from the bases of leaf stalks; they are finer, softer, and more pliable than true piassava. The dusky brown to black bristles are made into ropes of great strength and durability, or into soft brushes and brooms, and also serve as a substitute for horsehair and oakum.

Most of the supply of this fiber comes from Ceylon, and smaller amounts come from parts of India.

Raffia. Raffia is a flat, ribbon-like fiber derived from the cuticle of leaves of various species of palms of the genus Raphia--Raphia pendunculata, R. ruffia, R. toedigera, and T. vinifera.

Raphia ruffia, indigenous to Madagascar,[120] is the chief source of the fiber; but R. pendunculata, indigenous to Madagascar, R. toedigera (jupati palm), a native of the Amazon and Para River regions of eastern Brazil, and R. vinifera from West Africa, also supply some of the raffia on the world markets.

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117 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 48.

118 Ibid., p. 48.

119 Ibid., p. 48.

120 Otis W. Barrett, The Tropical Crops, The Macmillan Company, 1938, p. 341.

The Raphia palms are found growing plentifully in the wild state on the rich, alluvial, tide-flooded lands near the mouths of large rivers.[121] They are not systematically cultivated.[122] The palm leaves, varying from twelve to twenty-five feet are taken from the trees before they are fully expanded; the lower epidermis is stripped from the leaves and split into narrow strands by means of a kind of comb. These strips are usually three to four feet long and of a yellowish-brown or straw color.

Raffia fiber is tough, pliable, and almost impervious to water; hence, it is of great value as a tying material in nurseries and gardens, for weaving into mats, and fancy hand-made baskets. The United States imported 458 tons of raffia in 1935, chiefly for use as a tie material.[123]

Toquilla Fiber. The Panama hat industry depends solely upon the fibers obtained from the leaves of the so-called toquilla palm, or jipi-japa palm--Carludovica palmata--a fan-shaped tree of diminutive size, being only six to ten feet in height.

This species of palm is native to the equatorial rainfor-

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121 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 44.

122 Liberty H. Bailey, Cyclopedia of American Agriculture, Vol. II, 1907, p. 292.

123 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, 1937, p. 61.

ests of Ecuador and Colombia. Its present geographical distribution is limited to the Pacific tropical rainforest areas of South America and Central America. The toquilla palm thrives in a number of places in Ecuador--in the Pacific Coastal Lowlands, the lower Andean slopes of the Guayas Lowlands, the Amazon Basin of eastern Ecuador, and also in the intermontaine Basin of Cuenca. In Colombia this palm grows wild and is also cultivated extensively in certain parts of the humid forests of the Pacific Coastal Lowlands, the lower Andean slopes in the Atrato Valley,[124] and also in Caribbean Colombia on slightly higher lands and slopes.[125] Likewise, the dense tropical rainforest areas of the slopes of the Caribbean region of Venezuela favor the growth of this species of palm. For a long time Ecuador produced the entire output of the world's toquilla fiber, but the toquilla palm has been introduced into Panama and Honduras where its production now forms the basis of a small industry.

The toquilla palm is restricted to tropical rainforests because of its geographic requirements. It demands high temperatures and heavy rainfall--from 60 inches to 100 inches--both characteristic of the Tropical Rainy climate. This palm grows well on the heavy fertile soils of the tropical lowlands or the

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[124] Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 548.

[125] Ibid., p. 563.

lower slopes of mountains up to five thousand feet;[126] the soil must be humid, but fairly well-drained. In addition, the hat industry which is dependent on the toquilla fibers, or straws, necessitates cheap, painstaking laborers such as are found among the native Indians and mestizo workers in the equatorial rainforests of Ecuador and Colombia.

The gathering of the toquilla palm leaves represents a more advanced stage of forest-gathering, occupying the attention of many people. Although the toquilla palm thrives chiefly in a wild state, in some sections of Colombia, Ecuador, Panama, and Honduras it is a planted crop.

The young fan-shaped leaves of the palm--from five to seven feet long--are cut from the trees by native gatherers before the leaves open. These natives then strip the leaves of their outer filaments and then they are repeatedly dipped for a few seconds--over a period of ten minutes--in vats of boiling water and dried in the shade. After being cleaned, the straw or fibers from the leaves are bleached in the sun, after which they are ready to be woven into the so-called Panama hats, thus named because they were first sent via the Isthmus of Panama. The fibers from about six leaves are required to make one hat.

The Panama hat industry is concentrated in southwestern Ecuador (provinces of Manabi and Guayas where the famous Monte

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126 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 525.

Cristi and Jipijapa hats originated) and in the western part of highland Colombia (from the mountain town of Medellin to Pasto).[127] In these regions the population is fairly dense, the labor cheap, the laborers painstaking. Hats are also woven in many towns of the lowlands and on the western slopes of the Andes in Ecuador, Colombia, and even in northern Peru. The hats woven in remote villages are bought up by native traveling buyers who deliver them to exporting companies.

The weaving of the hats from the toquilla fibers is done by women and children, chiefly, who are skilled at this art. The weaving is done by hand usually during the early morning hours or evening when atmospheric conditions are humid, as dampness is essential and favors the making of the best Panamas.[128] As a result of this requisite it takes days or even weeks to complete a hat. The cheaper hats are woven in ten days while the finer hats may take as long as three months.[129] After being woven by hand, the men pound powdered sulphur into the hats with wooden mallets which smooth the straws. The hats are next bleached in sulphur fumes in an oven, and later bleached further in the sun. Thus an enormous amount of labor is required to produce a fine Panama hat. Although the best of these

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127 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 525.

128 Ibid., p. 525.

129 Clarence F. Jones, Economic Geography, Henry Holt and Company, 1935, p. 242.

Panamas bring from $12 to $25 each in the stores, the natives rarely get more than a dollar or two for each hat.[130]

Not only the Panama hat but hammocks and straw cigar holders made from toquilla palm fiber find their way to the markets of all parts of the world, especially the United States and Europe. A steady demand for the Panama hat exists in South American countries where they are worn by all classes of people.

The Panama hat industry of Ecuador has recently found competition from those foreign countries which import the straw and who have also begun to make hats in competition with the Ecuadorian product. Market competitions from cheap imitations and import duties placed by various countries upon the Ecuadorian hats have resulted in decreased shipments. The suggestion for increasing the output of Ecuador and Colombia by better organization and employment of more laborers in the industry has been offered as a possible solution for the decline in this hat industry.

FRUITS

The Tropical Rainy climate furnishes mankind with many different kinds of tree fruits. Though edible, not all of these are worth eating. Many have only local popularity; few are universally known or liked. Therefore, though there are

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130 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 526.

many more tropical fruits grown principally within the limits of this climatic region, only those which are of commercial importance, or have possible future importance on the world markets, will be considered. The following have been selected for discussion: the avocado, the breadfruit, the carambola, the durian, the guava, the lime, the mango, the mangosteen, the papaya, the sapodilla, and the tamarind.

The Avocado or Alligator Pear. The avocado is a fruit vegetable; technically it is a fruit, but its use in salads causes it to be looked upon and treated more as a vegetable than as a fruit. It is one of the most highly prized of the tropical fruits and is one of the most promising new food fruits for warm climates.

The avocado--otherwise known as alligator pear or midshipmen's butter--is a yellowish-green, pear-shaped fruit of the avocado tree (Persea americana and Persea gratissima). Each fruit weighs from one to four pounds and contains a single seed as large as a hen's egg. Properly ripened, the fruit has a firm, buttery consistency, and contains twenty to thirty per cent edible fat, considerable carbohydrate material, and more protein than any other fruit.

The native home of the avocado is in tropical America, its place of origin probably being Mexico.[131] The tree has been

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131 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 446.

found in the forests on the banks of rivers, and on the seashore from Mexico and the West Indies as far as the Amazon.[132] The avocado is extensively grown in native plantings in tropical countries: in the South American countries of Peru, Colombia, and central Venezuela; the Central American countries of Guatemala and Costa Rica; Mexico; and the islands of the West Indies and the Lesser Antilles. With the increased use of alligator pears in the United States, the tree is now of commercial importance in a small number of places on the poleward limits of the tropics. In Florida the region in which avocado culture is at present conducted commercially lies south of Palm Beach on the east coast, and south of Tampa Bay on the west coast.[133] In southern California avocados are raised in orchards in the coastal belt between Santa Barbara and San Diego on the hillslopes where lemons also are grown.[134] Here they are often marketed as calavos. The warmer sections of Arizona and New Mexico also are being planted with avocado trees. Because the avocado is of tropical origin, it is unsafe to plant it elsewhere in the United States where temperatures go below the freezing point, as only 4° to 5° of frost injures them seriously.

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132 Op. cit., p. 293.

133 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 24.

134 Ibid., p. 24.

The avocado is tropical in its climatic requirements, though it does not thrive in the very hottest parts, but grows better at slightly elevated stations.[135] High yearly temperatures and a high rainfall of 35 inches to 40 inches are necessary. This fruit tree cannot thrive where temperatures go below freezing, or where there is a lack of water. Therefore, in California irrigation is necessary because of the dryness of its summers. However, though the avocado will grow under irrigation where the summers are dry, it requires a humid atmosphere. Humidity is the limiting factor in parts of California, the tree being seriously injured by extreme dryness of the atmosphere.[136]

The avocado cannot thrive where the tree is subjected to heavy winds, for the large fruits are likely to be blown down. The lower east coast of Florida is occasionally visited by West Indian hurricanes which defoliate the trees, strip them of their fruit, and even uproot the trees.[137] Even certain parts of California are subject to occasional high winds capable of doing much damage. Therefore, in these regions the trees are kept as low as possible through pruning in an effort to escape damage by heavy winds.

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135 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 24.

136 Ibid., p. 28.

137 Ibid., p. 28.

In regard to soil, the tree thrives best in deep, sandy loams, but will grow in a wide variety of soils[138]--sandy loams of southern Florida, volcanic loams of Guatemala and Mexico, red clays of Cuba, granite soils of California, and even on heavy adobe. The chief requisite is good drainage and an ample supply of humus.[139]

In tropical countries the avocado tree grows wild or may be planted from seed by the natives near their huts. Where commercial culture is practiced, varieties are budded or grafted on seedling stocks and grown for one year in nurseries before transplanting into orchards. The trees receive cultivation practices quite like that given the citrus fruits.

The tree bears the third or fourth year from seed, and the sixth or seventh year after budding or grafting. Commercial bearing begins anywhere from the fifth to eighth year.[140] Mature groves produce as much as 500 crates per acre, forty fruits to a crate.[141]

The harvesting season occurs from July to January or February. Orange clippers are used for harvesting; the fruits are cut off with the orange clippers just above the swollen portion of the stem. As the trees are easily injured, ladders are not

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138 Samuel Fraser, American Fruits, Orange Judd Publishing Co., Inc., 1924, p. 679.

139 Ibid., p. 679.

140 Ibid., p. 677.

141 Ibid., p. 685.

reared against them as in apple harvesting, and so these clippers are attached to special long bamboo poles, the fruit dropping into a canvas bag sewed to a steel ring just below the hook. The fruit must be picked and handled carefully, as bruised fruit is not marketable. Tree ripened avocados have the best flavor, but fruits will ripen off the trees and may be picked a week or two before fully ripened. If the fruit is to be shipped, it must not be overripe by the time it reaches the market. If the avocadc is allowed to remain on the tree too long, it will drop off, and if gathered too early it lacks flavor. When ripe, the fruit must be used within a few days.

After gathering, the avocados are graded into uniform sizes, wrapped in heavy paper, and packed carefully in a single layer in excelsior in light wooden boxes.

Because of the relatively high cost of avocados, they are not yet sold in any considerable amount in temperate regions. Outside the tropical regions avocados are consumed only on a small scale, in the northern and eastern markets of the United States. Thus far, in the North American markets the avocado has been regarded as a luxury fruit for salads and special dishes, but a well-planned advertising campaign could probably put it into the food-fruit class with bananas.

It is one of the most promising of the new food fruits for the warm climates. Outside the American tropics it is a rarity. There is a great field of expansion for it in the warm regions

of Africa and Asia, but trials to date in those regions have been discouraging.

The Breadfruit. The breadfruit (Artocarpus communis) is one of the most important food fruits in the world. Few plants furnish a more wholesome food for man, or have a greater yield. The prickly fruits are round or globular, somewhat resembling a melon in shape and size; it has a heavy greenish-brown and yellow-brown rind, inside of which there is a white starchy mass that looks much like bread dough when baked. The fruits are borne in small clusters of two or three on the small branches of the tree upon short, thick stalks.

Breadfruit is a native of the Malay Archipelago (particularly the Sunda Islands)[142] from which its cultivation has spread widely to the tropical Pacific islands, being of considerable importance in Polynesia. Westward from Polynesia and its native home the breadfruit is grown in Ceylon and in parts of India. Tropical Africa and Australia have varieties which are valuable food producers. In the American tropics it is nowhere an important product, but it is cultivated on a limited scale in the West Indies, the lowlands of Mexico and Central America, and on the South American mainland as far south as the state of São Paulo in Brazil.[143]

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142 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 442.

143 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 411

There is probably no place in the United States where breadfruit can be cultivated successfully. All parts of California are unquestionably too cold for it. Even in extreme southern Florida where trees have been planted, so far as is known none has ever reached bearing age.

The climatic requirements are strictly tropical. The tree requires a warm humid atmosphere throughout the year, copious precipitation, moist fertile soil, and thorough drainage.[144] The absence of any of these conditions may wholly prevent the fruiting of breadfruit. Therefore, the physical requirements limit breadfruit trees to regions well within the Tropical Rainy climate.

Though many of these trees grow in a wild state, plantings of a few trees about a native hut for a food supply is found throughout the better portions of the equatorial rainforest.

Propagation is by means of root suckers and layering of branches--a method used even by the primitive natives of tropical regions. The breadfruit tree bears profusely two or three crops a year. An eight year old tree will produce about 700 to 800 fruits.[145] The fruit is gathered just before it ripens, for it is then that it is gorged with starchy matter.

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144 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 413.

145 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 401.

The breadfruit may be eaten baked or roasted, resembling wheat bread if properly baked. On the other hand, the fruit may be ground into flour after drying, or mashed and used in making poi. Very often the fruits are boiled, sliced, and served with butter, and provide a food tasting not unlike sweet potato.

The Carambola. A popular Indian fruit is the carambola, or as the British call it, the coromandel gooseberry. It is one of the most widely popular fruits in that country for sherbets, jellies, tarts, pickles, and preserves, as well as for dessert. Its star-shaped slices are often used to garnish fruit salads; when immature, for pickles.

Carambola is the fruit of an evergreen tree (Averrhoa carambola); the fruit varies in size from that of a hen's egg to that of a large orange, has a light yellow to orange colored skin, covering the watery pulp and the several flat brown seeds. The clear juicy pulp has a delicious flavor, sweet, subacid or tart, according to the variety.

The native home of this fruit tree is not definitely known; it is believed to be indigenous to the Malayan region, whence it was early brought to America.[146] It is now cultivated in the Malay Peninsula and the islands of the East Indies,

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146 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 430.

southern China, India, the West Indies, the warm parts of Central America and Mexico, Brazil (most abundant area of American production),[147] and to a small extent in southern Florida and southern California.[148]

In its climatic requirements the tree may be considered tropical.[149] It withstands very little frost and when young is injured by temperatures above the freezing point. It prefers a warm moist climate and a deep rich soil, but it can be grown successfully on sandy soils and heavy clays, and in northern India it thrives where the climate is dry. Cold is the limiting factor in California and Florida.

Propagation is readily effected by budding, cuttings, or by means of seeds. The tree may bear three years after planting. The tree is long-lived and a constant bearer, producing several crops a year. The fruit ripens in November and December, and is gathered when immature in some instances, especially if the fruit is to be used as pickles; the ripened fruit of sweet varieties may be eaten out of hand; sour varieties make excellent preserves.

The Durian. The durian is one of the most interesting of

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147 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 430.

148 Samuel Fraser, American Fruits, Orange Judd Publishing Co., Inc., 1924, p. 695.

149 Op. cit., p. 431.

all tropical fruits. It grows on a rather large tree (Durio zibethinus). The fruit weighs four to eight pounds, or more, and is almost the size of a man's head. It is covered with sharp conical spines so that it cannot be held in the open hand in safety. The custard-like pulp and seeds are edible portions, having an obnoxious odor which seems to be a mixture of garlic, Limburger cheese, and some spicy sort of resin.[150] After eating a bit, preferably with the nose held, the odor is scarcely noticed by the eater. This extremely offensive odor is a serious obstacle to the popularity of the fruit.

The durian is believed a native of Borneo and other islands of the Malay Archipelago. The region in which the tree is commonly found extends from southern Burma and Thailand (to the thirteenth and fourteenth parallels), southward through the Federated Malay States and the East Indies, particularly in Sumatra, Celebes, the Moluccas, Java, Borneo, and as far northward as Mindanao in the Philippines.[151] Only a few are grown in the western hemisphere due to the prejudice against the odor of the fruit.[152] Rarely is the tree cultivated in any region, growing in a hit or miss fashion around the thatched huts of the natives in the regions of Tropical Rainy climate. At best

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150 Otis W. Barrett, The Tropical Crops, The Macmillan Company, 1938, p. 202.

151 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 421.

152 Op. cit., p. 203.

it is a semi-cultivated fruit.

The durian is strictly tropical in its climatic requirements. It will not succeed anywhere on the mainland of the United States. It is limited to regions free from frost, and delights in deep rich soil and abundant moisture.[153] Therefore, there are many places in the West Indies and elsewhere in tropical America where it should be quite at home, but because there is no demand for it, no attempts have been made to propagate it here.

When ripe, the fruit falls off itself and is much sought after by native people and by animals as well. One tree yields as many as 200 fruits a year. Not only are the fruits sought after, but each fruit contains ten to twelve seeds as large as pigeons' eggs which, when roasted, are similar to chestnuts. The nuts are sometimes ground into flour and also are used as vegetable ivory.

Durian is not an article of commerce in any large quantity because of the objectionable odor and also because it does not stand transportation well. It should become an extremely popular fruit once the prejudice against the odor disappears.

The Guava. The guava is preeminently a fruit for jelly-making and other culinary purposes. It is the least exacting of all tropical tree fruits in cultural requirements, for it

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153 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 421.

grows and fruits under such unfavorable conditions, and spreads so rapidly by means of its seeds, that it has become a pest in some regions. The fruit is of commercial importance in many countries, and one whose culture promises to become even more extensive than it is at present.

The common guava of the tropics (Psidium guajava) bears an apple-like fruit. The flavor is sweet, musky, and very distinctive in character.

The native home of the guava is continental tropical America, probably occurring from Mexico to Peru.[154] The plant was carried to India at an early date, where it has become naturalized in several places. It is now cultivated throughout the Orient. In Hawaii it has become thoroughly naturalized. The guava is now well-distributed throughout the tropics and subtropics.

In the United States, the two regions in which guavas can be grown are Florida and southern California;[155] in Florida it is successful as far north as the Pinellas peninsula on the west coast and Cape Canaveral on the east; in California it can only be grown successfully in protected situations--at Hollywood, at Santa Barbara, at Orange, and in other localities.

The guava is successful on practically every type of soil.

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154 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 445.

155 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 274-5.

While not strictly tropical in its requirements, it can not be called subtropical. Within the tropics it is found at all elevations from sea-level to 5000 feet, and it withstands light frosts in California and Florida. The vitality of the guava is so great that it quickly recovers from frosts which may seem to have damaged it severely. As far as moisture is concerned, it has been stated that the guava prefers a rather dry climate.[156]

The tree is a heavy bearer and ripens its fruits during a long season, in some regions being obtainable throughout the year. Bearing commences in three or four years after planting from seed, while budded plants may bear fruit the second year after planting in the orchard.[157] The trees bear heavily for fifteen to twenty-five years. Some may bear fruit for forty years or more. The ripening season in India is November to January; in Florida and the West Indies it is in late summer and autumn.

The fresh guavas may be eaten in many ways, out of hand, sliced with cream, stewed, preserved, and in shortcakes and pies. Commercially it is used to make the well-known guava jelly. In Brazil a thick jam is manufactured and sold extensively. A similar product is made in Florida and the West Indies under the name of guava cheese and guava paste.[158]

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156 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 276.

157 Ibid., p. 278.

158 Ibid., p. 276.

The Lime. The lime (Citrus aurantifolia) is one of the sourest fruits on the market. Unlike the other citrus fruit trees it is distinctly tropical in occurrence. Limes are small greenish-yellow in color, thin-skinned, with an abundant acid pulp. Though not suitable for eating, they are grown chiefly for the juice.

The evergreen tree which bears this fruit is native to India and southern China. Because it is very susceptible to the cold, it is distinctly tropical in its present location. Limes are of commercial importance only to a small extent in Italy, California, and southern Florida. They are now extensively cultivated in the West Indian islands of Dominica and Montserrat, Jamaica, and nearby Trinidad.[159] Some cultivation is maintained in the Florida Keys and on the mainland of Florida, but only in the extreme south, as the lime is very subject to injury from winter cold.[160] In 1935 Florida produced 10,000 boxes of these limes.[161] Though the trees grow well in California, there is little cultivation there because of its extensive growth in the coastal lowlands in Mexico and the cheapness of the Mexican product. Some limes are also produced in southern Europe, particularly Italy, and in India, China, and the Guianas of South

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159 H. Harold Hume, The Cultivation of Citrus Fruits, The Macmillan Company, 1926, p. 133.

160 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 436.

161 Op. cit., p. 132.

America as well.

Lime is the commercial citrus fruit most tender to frost. This factor restricts its culture to regions of comparative freedom from even light frosts. Temperatures below 30° F.[162] cause injury to the tree by frost, necessitating orchard heating when planted in cooler parts of the subtropics. The lime is sensitive to sudden heat waves which may cause the dropping of young fruit. Comparative freedom from wind is necessary in regions of production because the rind of the fruit is easily injured in heavy winds and bruises result in scabby conditions which affect the salability of the fruit. Irrigation is necessary in drier regions of little or no summer rainfall because of the shallow rooting habit and high water requirement of lime.

Soils for orchard development should be light, or moderately heavy and well-drained. Deep soils are not required because of the shallow rooting habit. Much fertilization is necessary to provide good yields. The lime will stand poorer, stonier soils, and nearer proximity to ocean than any of the other citrus fruits.[163]

Trees for orchard planting are grown in nurseries where they are propagated by shield-budding or by cuttings. Though the first fruiting commences when the tree is three years old,

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162 J. Eliot Coit, Citrus Fruits, The Macmillan Company, 1915, p. 242.

163 Samuel Fraser, American Fruits, Orange Judd Publishing Co., Inc., 1924, p. 667.

commercial bearing doesn't occur until the fifth to seventh years.[164] The tree fruits annually; the fruit ripens almost continuously through the year, with the heaviest production in winter and summer months. Fruits are allowed to ripen if lime juice or oil of lime is desired. If green limes or pickled limes are desired, the limes are removed by clipping when the most desirable size is attained. If ripened (yellow) fruit is wished, it is allowed to remain on the tree and is gathered as it falls to the ground.

The United States derives its limes chiefly from Florida and the West Indies. In this country they are valued for citric acid and the lime juice which is obtained from them. Fresh green limes and pickled limes are sold to some extent in the United States. Very often the juice is extracted and shipped in a raw or concentrated form to the United States. Lime juice is used in beverages, as a source of citric acid, and medicinally to prevent scurvy. The oil of lime is expressed from the rind.

The Mango. The fruit of the mango tree (Mangifera indica) is one of the oldest and most highly esteemed of tropical fruits. It is well-known over the whole tropical world just as the apple is known in the temperate world; so it is often termed the "ap-

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164 Samuel Fraser, American Fruits, Orange Judd Publishing Co., Inc., 1924, p. 666.

ple of the tropics".[165] Next to the banana it is the most common of the tropical fruits, and is also one the most promising.

The fruit is a fleshy drupe with a thick yellowish-red skin and a large seed. The size, shape, and quality of the mango varies greatly with the region of production. It is somewhat oval-shaped, and varies in size from that of a small hen's egg to that of a large apple, weighing as much as four to five pounds each. The yellow or orange-yellow flesh is juicy, and has a rich, luscious, aromatic flavor with a perfect blending of sweetness and acidity.

A native of southeastern Asia, the Molucca Islands, the Andaman Islands, and particularly in India at the base of the Himalayas up to elevations of 3500 feet or more, it is now most extensively cultivated in nearly all tropical and subtropical countries of the Old and New World. In India the cultivation of the mango has spread over the Indian peninsula and now is grown everywnere on the plains of that country. In many parts of the Philippines, Malay Archipelago, and Polynesia mangoes are plentiful.[166] Mangoes are common along the tropical coasts of Africa, extending southward to the Cape of Good Hope, and also in Madagascar.[167] In the Mediterranean region the species

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165 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 368.

166 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, 1920, p. 89.

167 Ibid., p. 89.

is not entirely satisfactory. Production of mangoes is limited in Australia to the northeastern coastal area of Queensland.[168] Mangoes were introduced throughout the West Indies, especially in Jamaica on the hillslopes in the southern part of the island, into Haiti, and into Porto Rico. In the United States the cultivation of the mango is limited to southern Florida and southern California. The extreme southern part of Florida--from Palm Beach on the east coast and Punta Gorda on the west coast down to the southern end of the peninsula--is the most promising part of the United States for mango cultivation;[169] the largest commercial plantings here are in the vicinity of Miami. Thus far commercial mango culture has never been considered promising in California. In South America mangoes are grown on river banks in Caribbean Colombia, in the Maracaibo Lowland on large plantations along with cacao and sugar cane, but it is only for local consumption, and as a minor commercial crop in small forest clearings along the Pacific margin of Ecuador in the Atrato Valley.

The climate is of prime importance in the culture on mangoes, being much more so than soil.[170] Mango requires a yearly rainfall of 30 inches to 50 inches; the total rainfall is not so

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168 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 89.

169 Ibid., p. 99.

170 Samuel Fraser, American Fruits, Orange Judd Publishing Co., Inc., 1924, p. 752.

important as the season when it occurs.[171] Best crops are produced where there is a dry, sunny season when the trees are in bloom, and when the fruit is ripening; and a wet season in between those periods. It seems that the tree requires the stimulus of the dry season to fruit abundantly. The leeward side of tropical islands furnish the needed environmental conditions. In California the dry climate seems to stunt the trees but causes them to bear at an early age and yield abundantly.[172] Under such conditions as exist in California considerable irrigation is needed.

Frostless regions are preferred because the young trees are easily injured by frost; but when they reach full maturity, they will endure a temperature of 28° F. to 29° F. for a short time without injury.[173] In California, regions back from the coast are better suited to the fruit than the vicinity near the sea, because the latter is too cold and there is not sufficient heat to ripen the fruit.

Strong wind and rains, especially at the time of flowering, sometimes results in the trees failing to set a good crop of fruit.

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171 Samuel Fraser, American Fruits, Ornage Judd Publishing Co., Inc., 1924, p. 752.

172 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 99.

173 Ibid., p. 98.

The mango can be grown successfully on soils of several different types provided they are well-drained. Thus we find it grown with excellent results on deep, sandy soils, clayey soils, deep, rich alluvial loams. Much more important than mechanical or chemical composition is the drainage of the land. Trees cannot be expected to fruit profusely if the subsoil is permanently wet or poorly drained.

Mango trees are grown throughout the tropics in plantings of a few to many irregularly planted trees, and are seldom grown in numbers in regular orchard form, although future demands may result in a greater development of the orchard industry.

The common practice in the East is to raise mango from seed, but such trees have a low production. In India in-arching is practiced. In the United States where mangoes are grown commercially, grafting and in-arching onto pot-grown two year old seedlings is practiced. For the first few years the young trees need to be well-manured. Irrigation must be used in orchards in California. Usually little pruning is given other than to shape the head of the trees.

The period of gestation is from three to four years, but the tree takes a little longer to come into bearing in Florida than in the tropics--from four to six years. Commercial bearing begins from five to seven years, and lasts over fifty years. Most varieties produce annually from a few hundred to several

thousand fruits in a season. Very often two crops are possible. Other varieties--as Mulgoba in Florida--bear a crop only once in four years.

The fruit is harvested when fully ripened. For local use they may be allowed to soften slightly, and are shaken off the tree, so they can keep only a short while. For shipment the fruit must be harvested before it is fully colored and must not be allowed to become soft. For this purpose the fruit is cut from the tree with shears, leaving a short stem on the fruit. If the fruit is pulled, the sap may run out from the stem end and disfigure the fruit. The mangoes are carefully packaged in baskets for shipment. In Florida the shipping season is from July to October, with the main movement in August and September.

Fancy mangoes are shipped from India to London, Jamaica to London, French West Indies to Paris, West Indies and Florida to the northern markets in the United States (in normal times). The imports and use of mangoes are growing, but is as yet somewhat limited because of the prevailing ignorance concerning the fruit.

Mango furnishes food for at least one-fifth of the world's inhabitants.[174] The total production is estimated to be over

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[174] Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 95.

100,000 tons.[175] Ninety-nine per cent of this fruit is eaten fresh. Unripe fruits of culinary varieties are preserved, pickled with spices, or made into jams, pies, sherbets, iced drinks, or chutneys.

Probably no other tropical fruit could serve as the sole article of diet so long as the mango; in some regions the inhabitants eat practically no other food for weeks.

The Mangosteen. The mangosteen (Garcinia mangostana)--"the Queen of Fruits"[176]-- is considered the most delicious, best flavored, and most wholesome of all the world's fruits, and is highly prized in regions wherever it is grown.[177]

The size and shape of the fruit is similar to that of a middling-sized orange; but in color it ranges from dark brown to dark purple, spotted with yellow or gray. Within the thick rind the pulp is snow-white with crimson veins; the flesh is so delicate that it melts in the mouth like ice-cream. There is very little fiber to the pulp and it exudes a yellow juice of an exquisite flavor. The fruit does not bear shipping well, so it is little known outside the regions of cultivation.

The mangosteen is one of the most localized among the cultivated plants in its origin, habitation, cultivation, and use.

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175 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 451.

176 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 390.

177 Op. cit., p. 452.

This fruit tree is a native of the Sunda Islands and the Malay Peninsula.[178] It is now extensively cultivated in Java, Cochin-China, and Cambodia. Recently it has become common in Ceylon. A few trees have been introduced into the West Indies--Dominican Republic, Porto Rico, Trinidad--and tropical parts of Africa. The fruit is yet unavailable in the United States. The United States Department of Agriculture has spent a large amount of time and money in introducing the mangosteen and a number of sister species into Hawaii and the tropical portions of the United States. Attempts to grow mangosteen in southern Florida and southern California have not been very successful there since this tree is highly susceptible to possible frost injury.

Garcinia mangostana is strictly tropical in its requirements of temperature and rainfall, and in its demands in regard to soil conditions.

The mangosteen tree grows very slowly. Seedling trees may begin to bear fruit in seven or eight years, but rarely before the ninth or tenth year.[179] The tree produces two crops a year, one crop being heavier than the other. After fruiting begins, the tree bears for many years, being a sure and heavy cropper.

Mangosteens are eaten fresh; but they are little known and

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178 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 440.

179 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 390.

used outside the tropics because they do not readily stand transportation.

The Papaya. One of the important fruits contributed by tropical America is the papaya which is now grown throughout the equatorial lands.

The papaya fruit is melon-like in appearance, yet growing on a tree (Carica papaya). The fruit--football shaped, but usually only half as long--may weigh up to twenty pounds. The ripened fruit has a thin skin, and the flesh is orange or yellow, with a large cavity full of black seeds. Though somewhat mucilaginous, the pulp is delicious in flavor.

The exact area in which papaya originated has not been determined, though it is believed to be native to tropical America.[180] Today the papaya is cultivated in most tropical countries, the most favorable locations being in regions of Tropical Rainy climate, so it has been introduced only in limited numbers to select portions of the Humid and Mediterranean Subtropical climates.

The fruit tree is abundant in India, Ceylon, Malay Archipelago, Liberia, and Guam. The heaviest producer so far is Ceylon, while the largest fruits are found in Guam. The tree is common in Australia where it is cultivated as far south as Syd-

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180 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 293.

ney.[181] In tropical America the West Indies, Bermudas, Montserrat in the Lesser Antilles, and Colombia are fair producers. In Hawaii the papaya is now an important crop, second only to the banana, and it has become a valuable part of the diet there. In the United States the papaya has become naturalized on the Florida Keys and is grown successfully throughout southern Florida below Palm Beach; but it has not reached any great success in California, though it is sparingly grown in the hot interior valleys and foothills in the most protected situations. Other minor regions of papaya production are around Bahia in Brazil, Mexico, Panama, East Africa, and the Philippines.

In tropical regions the trees are raised about the native huts while in the poleward limits small orchards are being developed. With an increased demand for this fruit as it becomes more widely known, its cultivation will increase in orchards.

Papaya is tropical in its climatic requirements, but it can be grown in regions where light frosts are experienced. It will survive winters where the temperatures do not go below the freezing point. One good frost will kill the tree, and too much near frost will prevent its fruiting. In California, except in specially favored localities, the nights are too cool. Because of the danger of winter frosts in northern and even central Florida, it will never be planted there for commercial pur-

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[181] Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 278.

poses.

The papaya requires considerable rainfall. Cold rains are detrimental, especially if the soil drainage is deficient, causing the plants to rot at the base. Then where the rains are too great, they do not favor fruit ripening.

A rich, loamy, well-drained soil is preferred, though the tree will grow on a variety of soils if all other conditions are favorable.

In the past most papayas have been grown from seed, but the uncertainty of the seedage process is giving way to graftage. The tree makes very rapid growth. Trees grafted in March begin to bear commercially in November or December, continuing through the following spring and summer, and even the fall months. Each tree produces a crop of twelve to thirty fruits. Trees do not usually bear profitably more than three to five years even under the most favorable of conditions, so plantings are made either annually or biennially, and planters only allow the trees to fruit for one or two years.

The fruits are harvested as soon as the skin surface begins to turn yellow, though for long distance shipment they must be picked green. The difficulty of shipping limits at present the spread of papayas to American markets, for even by fast express there is much loss, and the fruit is not nearly so good as when tree-ripened. The United States is the heaviest consumer outside the tropical regions of production.

The papaya is used chiefly as a table fruit, but it is possible to employ it for salads and pickles, or even to cook it as a vegetable, when it resembles summer squash.

Immature fruits when scratched exude a thin whitish latex, the source of papain, which coagulates soon on exposure to air. Depending on the size of the fruit, from five to ten ounces or more of dried latex may be obtained from each tree in a year. Each fruit should be tapped three to six days a week as long as it yields latex and should be continued throughout the year, by lightly cutting or scratching the thin pericarp early in the morning, and catching the latex in some receptacle. The latex then should be spread out in the shade where the wind can reach it, and the gum thus allowed to dry. Montserrat in the Lesser Antilles turns out a good grade of gum in large quantities.[182] The powdered or flaked gum is used chiefly in the chewing-gum industry, and in medicine; the standardized extract, papain, is a valuable vegetable pepsin. Considerable quantities are imported from Ceylon, the United States being the heaviest consumer in the northern markets of the world.

Hitherto, the papaya has not been popular in the northern markets, but it bids fair to attain a considerable place in the markets of the world as a result of recent improvements in pro-

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182 Otis W. Barrett, The Tropical Crops, The Macmillan Company, 1938, p. 201.

ducing better shipping varieties, and improvements in methods of packing and handling.

The Sapodilla. The sapodilla is considered one of the best fruits of tropical America. The fruit is commonly round, oval, or conical, and two to four inches in diameter, bearing a striking resemblance to an Irish potato. The flesh of the ripe fruit is yellow-brown, translucent, soft, sweet, and delicious.

The sapodilla tree (Achras sapota) is native to tropical America--Campeachy, the Isthmus of Panama, and Venezuela.[183] From its native home it has been carried around the world. It is grown on the western coast of India and in Bengal. The tree can be found in some parts of Africa, and it is common in the Hawaiian Islands. Throughout tropical America it is abundant from southern Brazil to Florida.[184]

In California the sapodilla has not been a success. In Florida its cultivation is limited to the east coast from Palm Beach southward to Key West, and on the west coast as far north as the Manatee River. On the Florida Keys the sapodilla is one of the favorite fruits.[185]

Achras sapota is tropical in character, but does not re-

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183 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 445.

184 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 336.

185 Ibid., p. 336.

quire a high degree of humidity nor entire freedom from frost. If liberally irrigated it can be grown in regions where the atmospheric humidity is low. It will thrive on rich sandy loams and light clays.

Seedling sapodillas rarely come into bearing until six to eight years of age. Usually they fruit heavily, often producing two crops a year, one being lighter than the other.

Sapodillas are distinctly dessert fruits. Generally they are eaten out of hand. Sometimes they are used in making sherbets.

The chief commercial product of the sapodilla tree, however, is not the fruit, but the milky latex which is the chief source of chicle. (See pages 157 to 161.)

The Tamarind. Tamarindus indica is a huge dome-shaped tree of the pea family, which bears large cinnamon-brown, pod-like fruits--the tamarind.

The tree is believed to be a native of southern Asia and tropical Africa.[186] It has long been cultivated in India, and was early introduced into tropical America and the West Indies. It is grown to some extent in southern Florida as far north as Manatee.[187] No part of California, however, is climatically

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186 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 459.

187 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, Inc., 1920, p. 432.

suited for growing the tamarind.

The tree does best in a deep alluvial soil and abundant rainfall; but will make good growth if liberally irrigated. It is usually given little cultural attention, and is not grown as an orchard tree.

The tamarind is propagated from seeds. Seedling trees are slow to come into bearing. A mature tree is said to produce, in India, about 350 pounds of fruit a year.[188]

The fruit is of more considerable importance in Arabia and India than in the United States. In the Orient it is an ingredient of chutneys and curries, and is used in pickling fish. It is valued by the Hindus for its medicinal qualities. In Latin America, with the addition of sugar and water it yields a cooling drink, or refresco. In some countries tamarinds are an important article of export.

In Jamaica the fruit is prepared for shipment by stripping it of its outer shell, and then packing it in casks, with alternating layers of coarse sugar. Boiling sirup is poured over all. In the Orient the pulp containing the seed is pressed into large cakes, which are packed for shipment in sacks made from palm leaves. This product is a familiar sight in the bazaars, where it is retailed in large quantities; it is greatly esteemed as an article of diet by the East Indians and the Arabs.

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188 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, Inc., 1920, p. 435.

Large quantities are shipped from India to Arabia.

GUMS AND RESINS

Though no true gums of commercial importance come from the trees in the Tropical Rainy climate, a number of resins are importantly associated with this climatic belt. These resins are the non-crystalline solid or semi-solid organic substances produced by or exuded from trees, yellowish to brown in color, and soluble in alcohol, ether, or turpentine, but not in water.

Commercial resins from trees in the Tropical Rainy climate may be classified as follows: the gum resins, mixtures of true gums and resins with usually some essential oils,--gum elemi; the hard resins, used for varnishes,--copals, dammars, and kinos; and the oleoresins, liquid resins produced as mixtures with essential oils,--Balsam of Peru, Balsam of Tolu, benzoin, copaiba, and storax.

The Gum Resins

Gum Elemi. The term "gum elemi" is a collective name applied to a number of gum resins[189] of different origin which are used to give toughness and elasticity to varnishes. Elemis differ considerably in their characteristics; some are soft, while others are quite hard.

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189 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 304.

Manila elemi, the most important and best known of this gum resin, is the exudation from Canarium commune and Canarium luzonicum (pili tree),[190] a tree growing chiefly on the island of Luzon, in the Philippines. The clear pale liquid is secreted in the bark of the tree, oozes out from the trunk, and hardens on exposure into fragrant white to yellow, sometimes grayish, transparent masses which are collected by the natives who use it for torches and for caulking their boats. Besides its use in the varnish industry, Manila elemi finds uses in lithographic work, manufacture of inks, perfumes, medicines, plasters, and ointments.[191]

American and Mexican elemi is obtained from an allied tree, Bursera gummifera, and is darker in color than Manila elemi.[192]

The Hard Resins

Copals. The term "copal" is applied to a group of hard resins which are more or less soluble in alcohol and other solvents except after being melted. Their chief use is in the manufacture of hard elastic varnishes for both indoor and outdoor work. The copals are usually designated by the name of the region from which they are obtained. Imports of copals by the

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190 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 190.

191 Ibid., p. 190.

192 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 304.

United States in 1935 reached 20,447,942 pounds.[193]

East African Copals. The hard resins in trade called "East African copal" are obtained from Zanzibar, Mozambique, and Madagascar, and are known individually as Zanzibar copal, Mozambique copal, and Madagascar copal. These copals are derived principally from leguminous trees[194] --Hymenaea mossanticensis, Copaifera gorskiana, and Trachylobium verrucosum. The resin exudes naturally from the trunk, branches, and fruits. Most of the commercial supply, however, is obtained from semi-fossil material, derived from still living trees, and fossil material from trees no longer in existence.[195] The fossil copal is dug from the ground by native collectors. These copals are clear and transparent, varying in color from yellow to brownish-red. Zanzibar copal is the hardest of all tropical resins and is very valuable. Much of the resin is exported from Zanzibar to Bombay and thence to Europe.

West African Copals. Many different kinds of tropical trees growing in West Africa produce copals, but the most important are species of Copaifera, Hymenaea, and Trachylobium. These copals are usually found in a fossil or semi-fossil state, or may be obtained from living trees in a soft condition.

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193 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 172.

194 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 304.

195 Op. cit., p. 172.

Sierra Leone is the chief center of the industry, but copal is found in all parts of West Africa as far as the Portuguese Congo, and they appear on the market by the name of the region from which they are obtained.

The most important of the West African copals is Congo copal[196] (red or white in color); this copal has been extensively exploited in recent years. This West African copal is derived chiefly from Copaifera demeusii and C. mopane. Though living trees furnish some of the supply, by far the greater part is fossil in nature, being dug up from the grounds in districts where the trees formerly grew, or from river beds. This work is done by the natives who bring the collected material to coastal towns.

The best kind of copal is Sierra Leone copal,[197] a light yellow, hard, brittle resin, obtained from Copaifera guibortiana and C. salikounda. Here the living leguminous trees are tapped to produce soft resin or "fresh copal" which exudes and hardens on the trees in the form of globular tears. "Fresh copal" is of less value commercially than the fossilized type, which is found within this same region in the beds of rivers and is named Pebble Copal. Moreover, the method of tapping the living trees as employed by the natives has been so wasteful as to

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196 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 172.

197 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 304.

destroy them. So to safeguard the industry the government has restricted the export of "fresh copal", and plantations have been established in parts of Sierra Leone.[198]

From large trees, Daniella ogea and related species which are found in the coastal forests of Liberia, the Gold Coast, and Nigeria, a resinous exudation, known locally as ogea gum and commercially as Acera and Benin copals, is increasing in importance as a varnish resin.[199]

Manila Copals. Manila copal, which is a hard resin consisting of large, irregular, angular, milky pieces with a yellowish interior, first entered world trade from Manila, hence the name. Today, however, 75 per cent of the product is exported from the Dutch East Indies.[200]

The source of this copal is a tall conifer tree--Agathis alba--characteristic of the high grounds in the Philippines, Macassar, Borneo, the Moluccas, Celebes, and New Guinea.[201]

Though the resin exudes naturally, some is also obtained by systematic tapping, being soft when first obtained and hardening on keeping; the rest of the supply is derived from fossil material.

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198 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 304.

199 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 173.

200 Ibid., p. 174.

201 Op. cit., p. 304.

Pontianak copal from Borneo is the hardest variety and is especially popular in the United States.

Because of their solubility in either spirit or ether, Manila copal is used as the basis of many spirit varnishes and enamels, as it gives more elasticity than shellac.

South American Copals. The chief source of South American copal, or anime, is a tall locust tree, Hymenaea courbaril, which grows in Brazil, the West Indies, and other parts of tropical America.

The stems, twigs, and even the fruits of this tree exude a large amount of the resinous product, which trickles to the ground. The commercial resin is collected from the base of living trees, and former trees as well, and is marketed as Demerara or Para copal.

Of all the commercial copals, South American copal is the softest and so the least valuable.

Dammars. Dammars, a collective term for a great variety of hard resins used chiefly in varnish manufacture, are obtained from trees which are members of Dipterocarpaceae. Comparatively few members of Dipterocarpaceae secrete resin of commercial importance; these are found chiefly in genera Balanocarpus, Hopea, and Shorea.

True dammar is produced by a coniferous tree, Agathis dammara, growing in the Malay Peninsula, the Philippines, Sumatra,

Java, Borneo, Siam, Cochin China, and the Moluccas. The resin occurs as a natural exudation from the stem of the tree, or is obtained by a system of tapping by means of incisions. The resin exudes as a thin viscous fluid which hardens on exposure to the air, when it is then collected by native laborers. The resin varies from white to yellow and occurs in rounded transparent pieces with a powdery crust over the surface. Pieces vary in size from one-half to two inches in diameter. In normal times large quantities are sent to Singapore before export to Europe, but the grading and sorting is chiefly carried out in Batavia.

The most important variety of dammar produced in the Malay Peninsula is the resin from Balanocarpus heimii, and is sold under the name of Damar Penak. This variety is obtained from the forests of Negri and Sembilan. Other important Malayan varieties include Hopea micrantha and Shorea crassifolia. Before World War II more than half of the Malayan export was shipped to the United States.

Several resins similar to true dammar are derived from various Indian trees for use in India and the Far East. The principal dammars of India are "sal dammar" from Shorea robusta, "white dammar" from Vateria indica, and "black dammar" from Canarium strictum--the last two named being natives of the Malabar Coast.

The most outstanding commercial variety of dammar is the

so-called Batavian dammar, a product of Shorea wiesneri, a species found in Java and Sumatra.

The United States imported in 1935[202] varieties of dammars totaling 15,004,904 pounds for use principally in varnish manufacture.

Kinos. Kinos, or gum kinos, comes from several sources. A variety known as Malabar kino--the dried juice of Pterocarpus marsupium--is derived from a large Indian tree by first tapping the tree and then boiling down the juice until small, brownish-red, brittle pieces remain. West African kino is a red resin from P. erinaceus. Bengal kino comes from Butea monosperma. Several tropical American trees, chiefly Dipteryx odorata and Coccoloba uvifera, also yield kinos.

Kinos are chiefly used in medicine for throat trouble, and are used to some extent in tanning.

The Oleoresins

Balsam of Peru. This balsamic resin is obtained from the Myroxylon pereirae, a tall tree which grows in the equatorial rainforests in the state of San Salvador in Central America. It is cultivated in many tropical and subtropical countries. Its common name is a misnomer, for the tree does not grow in Peru.[203]

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202 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 193.

203 Ibid., p. 187.

The balsam is a dark, reddish-brown, thick, sirupy, viscous liquid, which does not dry on exposure to the air; and is a pathological product resulting from the wounding of the tree. It is obtained by beating the trunk of the tree with a blunt instrument. Then the injured bark is charred. Soon after, the bark falls off naturally, or is removed. This causes the balsam to exude from the exposed surface of the wood, and the exudation is collected on rags. The rags are later boiled to free the balsam, which is then purified.

Balsam of Peru is used in medicine for healing slow wounds and skin diseases. It is also used in the treatment of coughs, bronchitis, and similar ailments, because of its stimulative and antiseptic effect on the mucous membranes. It is utilized in perfumes as a fixative for heavy odors, and has served as a substitute for vanilla because it has an aromatic odor resembling that of vanilla.

The United States imports its supply chiefly from San Salvador, the imports in 1935 totaling 71,312 pounds.[204]

Balsam of Tolu. Myroxylon toluiferum, a leguminous tree of Central America, Venezuela, Colombia, and Peru, produces the pathological product known commercially as Balsam of Tolu. V-shaped incisions are made in the trunk of the tree, and the balsam, as it slowly exudes, is collected in gourds, and forms on

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[204] Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 193.

exposure to air, a solid or semi-solid mass. This soft brown or yellowish-brown plastic substance with its pleasant aromatic taste and odor becomes hard on keeping.

Balsam of Tolu finds many uses in the United States, which imports large quantities. In 1935 Central and South American countries exported 56,070 pounds of this oleoresin to the United States.[205] It is used in this country for salves, ointments, expectorants, and antiseptic in the treatment of coughs, colds, and bronchitis. Cough sirups are sometimes flavored with it. Considerable amounts, too, are used as fixatives in the perfume industry.

Benzoin. Benzoin is a solid balsamic resin, commercially known as "gum benjamin". It is obtained from various species of Styrax growing in the tropical rainforests of southeastern Asia and the East Indies, particularly in Siam, Java, Sumatra, and Borneo.[206] The best commercial grades, however, are obtained from Sumatra and Siam.

The balsam oozes out from deep incisions made in the bark of the trunk and branches, hardening upon exposure into yellowish, reddish, grayish brown (according to the species of Styrax) pebble-like tears with a milky white center. These are removed

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205 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 193.

206 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 130.

from the tree by a knife or chisel.

Benzoin is exceedingly aromatic, with a vanilla-like odor. It is used in medicine as a stimulant and expectorant, and in the preparation of heavy sweet perfumes, soap, toilet waters, lotions, with powders, incense, and fumigating materials.[207] Imports of benzoin by the United States in 1935, chiefly from Siam and Sumatra, reached 96,697 pounds.[208]

Copaiba. Known also by such names as copaiba balsam and copaiva, copaiba is a natural oleoresin obtained from several species of Copaifera, native to tropical South America.[209] The copaiba trees are small with strong, tough, durable wood, which contains resin ducts of large size. At times so much oleoresin is secreted and stored in the cavities that the pressure causes the trunk to burst open.

Copaiba is obtained by boring holes into the heartwood. The secretion flows out very rapidly, a thin, clear, colorless liquid at first, but turning yellow and becoming more viscid with age.

There are several commercial varieties of copaiba. The most important of these are Maracaibo copaiba from Venezuela, obtained from Copaifera officinalis, which contains considerable resin and is rather thick, and Para copaiba, a very fluid grade

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207 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 188.
208 Ibid., p. 193.
209 Ibid., p. 189.

from Brazil, obtained from C. langsdorfii. Balsam of copaiba is an important forest product from the lower Atrato and Sinu Valleys of Colombia.[210]

Copaiba is used in making varnishes, lacquers, and tracing paper. In medicine it is used as a disinfectant, laxative, diuretic, and mild stimulant. Of all the oleoresins imported from the climatic regions with the Tropical Rainy climate that of balsam of copaiba is the greatest; 187,914 pounds of this balsam were imported by this country in 1935.[211]

Styrax or Storax. The variety of styrax or storax that enters commerce from forests within the Tropical Rainy climate is called American styrax. This balsam is obtained from the sweet gum (Liquidambar styraciflua). Although this tree ranges from New England to Mexico and Central America, the commercial supply of styrax comes only from Guatemala, Honduras, and Venezuela.[212]

The balsam is formed as a result of wound stimulation. After the outer bark is bruised, the balsam exudes into the inner bark. The outer layers of bark are stripped and the balsam is recovered by boiling the inner layers in sea water. This balsam is a thick, clear, brownish-yellow, semi-solid or solid sub-

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210 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 549.

211 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 193.

212 Ibid., p. 188.

stance, and is used in soaps and cosmetics, as a fixative for perfumes, in lacquers and incense, as a flavoring for tobacco, in medicine as a stimulant to the mucous membranes and for the treatment of scabies.

LATEX PRODUCTS

A goodly number of commercial products of the North Temperate Zone depend upon the latex or milk-like juice occurring in the inner part of the bark of certain trees growing wholly within the forests of the Tropical Rainy climate. The chief latex products discussed will be balata, chicle, gutta-percha, jelutong, and rubber.

Balata. Balata is a non-elastic rubber which in industry serves the same purpose as does gutta-percha. (See page 164.) The latex is obtained from the Mimusops globosa, a magnificent tree growing to a height of over one hundred feet. This species is a native of Trinidad and of the tropical rainforests of South America.

Unlike gutta-percha, balata has never been cultivated, and probably will always remain a wild forest crop. The world's supply comes from the mountainous regions within the hot, humid forests of the Amazon Valley of South America where in many districts it is the leading forest product. In recent years the balata industry has acquired significance in Amazonia. Today the Amazon Basin is the world's chief source of supply, most of

the product originating in the Montaña district of Peru.[213] The Brazilian output aggregates more than one-fifth that of the world. In the Montaña district of eastern Peru the balata is of greater present significance than rubber.[214] The gum comes from all parts of that region, and is of good quality.

Other balata-producing areas of South America include the forested areas on the slightly higher lands and slopes of northern Colombia,[215] the Orinoco Basin of Venezuela,[216] and the Guiana Highlands.[217] In all these regions balata is the leading forest product. Balata is the Guianas' and Venezuela's[218] chief forest product. Here the tree occurs in scattered solitary specimens or in clumps throughout most of the forested areas.

The balata tree is most frequently encountered in mountainous regions. It prefers a red clay soil with ferruginous gravel along the slightly marshy margins of small streams. As many as forty to fifty trees grow to the acre. The average number of adult trees in the balata producing regions probably vary from

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213 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 503.

214 Ibid., p. 222.

215 Ibid., p. 563.

216 Ibid., p. 615.

217 Ibid., p. 675.

218 Ibid., p. 53 and 658.

two to fifteen per acre. A balata tree requires thirty to forty years to reach maturity, and many of them live to be over one hundred years old.[219]

The tapping season coincides with the rainy season when the yield is greatest. Generally a white supervisor enters the forest with a group of Indians to begin the arduous task of tapping the trees and preparing the sheets of balata. The extraction of the latex, known as "bleeding", is either done by tapping the standing trees, or by felling the tree and then tapping it.[220] By the felling method, all operations on a tree are more extensive and take longer, but the individual yield is said to be much greater. In felling, about six trees per day can be cut by one workman; a bleeder can tap five or six trees in the same time. Depending on the size and location, a balata tree yields from one to three gallons of latex at a tapping, or roughly four to fifteen pounds of balata.[221] The disadvantage of the felling method is that the felled trees are a complete loss as far as future production is concerned.

The balata tappers may remain in the forest for months at a time, being paid little and liable to a multitude of dangers, including snake bites, insect pests, and malaria. The work is

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219 Joseph W. Vander Laan, Production of Gutta-Percha, Balata, Chicle, and Allied Gums, Trade Promotion Series No. 4, 1927, p. 28.

220 Ibid., p. 29.

221 Ibid., p. 29.

hazardous, for the gatherers whose work season coincides with the rains and swollen rivers are often bitten by snakes, and the streams are full of paranhias, a poisonous fish.

The latex of the balata tree is obtained three times each year. The milky juice flows freely and readily coagulates in the air. After coagulation, the balata is cleaned and molded into cakes.

Balata contains about fifty per cent of gum, and so is often used as a substitute for chicle. It is also particularly well-adapted for machine beltings as it grips tightly and never stretches. It is also very valuable for making undersea cables.

The United States is one of the chief markets for balata, having imported 1,377,273 pounds in 1935.[222] Other importers before World War II were Germany, United Kingdom, and the Netherlands.

Chicle. Chewing gum, one of the "musts" in many an American's daily life, depends upon the milky juice--the latex--obtained from the bark of the zapote, sapodilla, or naseberry tree (Achras sapota), a native of the tropical rainforests of Mexico, Central America, the West Indies, and adjacent South America. The latex consists of a gum-like substance known as chicle, and is the basis of chewing gum.

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222 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 167.

Many zapote trees grow from southeastern Mexico and British Honduras to Brazil. In some parts of tropical America, the Philippines, and Florida where it has been introduced, it is cultivated for its edible fruit; but its most important commercial use is for the production of chicle. The tropical forests of northern Guatemala furnish the best chicle.[223] Yucatan in southeastern Mexico produces nearly the entire commercial supply. Ranking next to Guatemala, which is second in production, is British Honduras.[224] Outside Central America the Atrato Valley of Colombia and the Guianas have areas of commercial production of chicle.[225]

The zapote trees require the temperatures and rainfall such as is characteristic of the Tropical Rainy climate. There is a need of a particular rainy season because then the zapote tree yields the most latex. An abundant supply of cheap, skilled workers is necessary to maintain a supply to meet the demands. Furthermore, many regions where the zapote trees occur are not being exploited because of the lack of cheap and easy means of transportation from the "camps" to the ocean ports.

Chicle is obtained from the zapote trees which grow wild in forests which are generally owned by the government and sea-

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223 Clarence F. Jones, Economic Geography, Henry Holt and Company, 1935, p. 239.

224 Charles Landon, The Chewing Gum Industry, Economic Geography, XI (1935), p. 185.

225 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 549.

sonal permits at $45 to $60 an acre must be obtained for the purpose of gathering chicle there.[226] Thus it is largely a forest-collecting industry. Plantations are being established; but these are not very practicable for the trees should be tapped only once every two or three years, preferably only once in five years.[227]

The juice or sap of the tree is gathered during the rainy season, from May to October,[228] when the trees yield the most. The most primitive method of obtaining the chicle is to tap the trunk and then scrape the thickened exudate from the bark. Where the industry is carried on more extensively, the native collectors, or chicleros, are more careful. During the gathering season the chicleros live in the forests while gathering the sap. Because the zapote trees are scattered, it is necessary that each chiclero travel alone and cover a designated part of the forest. Early in the morning zigzag gashes are cut into the bark of the tree with machetes, beginning about eight inches from the ground, not quite encircling the tree, and continuing up to a height of thirty feet, each cut joining the one below so that the sap will run down. The chiclero is careful not to cut all the way through the bark, for if he does, the tree

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226 Charles Landon, The Chewing Gum Industry, Economic Geography, XI (1935), p. 185.

227 Ibid., p. 187.

228 Clarence F. Jones, Economic Geography, Henry Holt and Com- 1935, p. 239.

may die. The latex runs to the base of the tree where it is collected in rubberized bags, leaves, or even hollows in the earth. The flow of latex lasts for several hours, and the yields may be as much as sixty quarts. A full grown tree may provide thirty pounds of good chicle in a year.[229] The average chiclero collects about one ton of gum a season from 200 to 325 trees. After a season's tapping the trees should be allowed to rest from four to seven years.

Later in the day the chiclero collects the sap, takes it to his hut in the forest, strains it, cooks and stirs the sap until it thickens. Then it is cooled and kneaded by hand, as a baker kneads dough, to keep the chicle from becoming lumpy. The doughlike mixture is molded into blocks and wrapped in canvas and taken to the "hato" (main camp base). From here the chicle blocks are taken on mule back to the rivers, thence by boat to the ocean ports.

The chiclero gets ten dollars per one hundred pounds of good chicle that he turns in at the "hato". His average earnings per month amount to twenty-five to thirty dollars, but he seldom has this money long after the chicle-gathering season is over.

Most of the chicle is shipped to the United States, the greatest chewing-gum nation, and there it serves as the basis

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229 H. M. Hoar, Chicle and Chewing Gum, Trade Information Bulletin No. 197, Bureau of Foreign and Domestic Commerce, 1924, p. 4.

of that industry. The supply is exported chiefly from Belize in British Honduras.[230] In 1935 chicle imports reached a total of 7,775,221 pounds.[231] One pound of chicle as it comes from the final process, makes about 400 sticks of gum, a stick of gum being about 15 per cent chicle--the remainder consisting of sugar and flavoring substances.[232]

Conservation of the trees is an important consideration if future requirements for chicle are to be met. At present, the ruthless tapping and carelessness and ignorance cause the loss of many trees. Fear of a shortage of chicle has caused one American Company to acquire 355,500 acres of land and introduce plantation methods.[233] It is claimed that plantation methods are not applicable on any scale until better methods of tapping have been worked out. It will be a long time before much chicle will be obtained from plantations because of the many years required for a tree to reach maturity.

Gutta-Percha. Gutta-percha is a non-elastic rubber which is little known outside a limited circle. This non-elastic rubber is indispensable in the world's work. It is obtained

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230 Charles Landon, The Chewing Gum Industry, Economic Geography, XI (1935), p. 185.

231 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 167.

232 Clarence F. Jones, Economic Geography, Henry Holt and Company, 1935, p. 239.

233 Charles Landon, The Chewing Gum Industry, Economic Geography, XI (1935), p. 186.

from the grayish-white latex found in the sac-like channels of the bark, pith, and leaves of Palaquium gutta, a tree of Malayan origin.[234]

Though several members of the Sapotaceae family contain the latex from which gutta-percha is obtained, Palaquium gutta is the chief source. This tree now occurs in the Far East as far north as Indo-China and the Philippine Islands, and as far to the southeast as New Guinea. Within that region Boreno and Sumatra are important producers; in the Malay States there are said to be about 300,000 acres which can be considered as gutta-percha forests.[235] Other portions of the Tropical Rainy climate having wild gutta-percha trees are Peru, Brazil, Bolivia, Panama (all in Tropical America), and British West Africa.[236]

Though gutta-percha trees have been found at altitudes of 3000 feet, they are most frequent near the coast on areas not subject to floods.[237] The average rainfall in the regions where gutta-percha is most abundant is between 100 and 120 inches a year, with 150 to 200 rainy days; the annual average temperature, 79° F. The tree seems to prefer a humus-containing, porous, clay soil.

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234 Ernest E. Stanford, General and Economic Botany, D. Appleton-Century Company, Inc., 1937, p. 561.

235 Joseph W. Vander Laan, Production of Gutta-Percha, Balata, Chicle, and Allied Gums, Trade Promotion Series No. 4, Bureau of Foreign and Domestic Commerce, 1927, p. 7.

236 Ibid., p. 7.

237 Ibid., p. 8.

Pure forests of gutta-percha do not occur. The tree is scattered among others, many of larger size, and under natural conditions it is not the most abundant tree. However, such forests could be changed to almost pure gutta-percha forests by the gradual removal of other species. Plantations have been in existence since 1900 in the East Indies, but they didn't begin to yield supplies in marketable quantities until around 1927.

The latex or gutta-percha is produced in sacs which occur in the pith, leaves, cortex, and phloem of the tree. Usually the method of obtaining the milky juice from the trees in the wild forests is to fell the trees, though sometimes incisions are made in the standing trees and the milky juice flows out very slowly. After felling the trees the bark is removed in strips of one inch widths and one foot apart; the latex is caught in coconut shells or in palm or plantain leaves.[238] In estate practice, the old leaves are plucked regularly four times a year or two, and the gutta is extracted by crushing.[239]

The gutta-milk coagulates into a grayish-yellow mass which is purified by washing in hot water. Then the whole mass is boiled and kneaded into blocks. Sometimes the coagulated mass is chopped or sliced up, and the pieces are washed, strained,

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238 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 167.

239 Joseph W. Vander Laan, Production of Gutta-Percha, Balata, Chicle, and Allied Gums, Trade Promotion Series No. 4, Bureau of Foreign and Domestic Commerce, 1927, p. 8.

kneaded, and then rolled into thin sheets.

Gutta-percha deteriorates rapidly in air and so should be kept under water, since it is highly impervious to water. This fact makes it important in the construction of submarine cables which require a material resistant to salt water, pliable, and with the proper amount of rigidity; no other material can replace gutta-percha for this use. Because gutta-percha is an exceedingly poor conductor of heat, it is much used for insulation. At ordinary temperatures gutta-percha is hard, so it has other uses: splints, supports, pipes, golf balls, speaking tubes, telephone receivers, waterproofing, and adhesives. It is also utilized for protecting wounds and in dentistry. The United States imported a total of 3,588,728 pounds of gutta-percha in the year 1935.[240]

Jelutong. Jelutong comes chiefly from Dyera costulata and species closely related to it, all of which are natives of southeastern Asia. At present the trees are found principally in the forests of Borneo, southern Sumatra, and British Malaya.[241] The trees have been exploited to some extent on plantations under European control, particularly in Malaya, Sarawak, and Borneo.[242] Greatest commercial production of jelutong un-

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240 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 167.

241 Op. cit., p. 62.

242 Ibid., p. 62.

til World War II was restricted to Malaya. Malayan trees have an astonishing flow of latex, greater than all the other latex species together.

Much of the latex is obtained from native forests, which are under government control, by tappers who secure permission from the authorities to collect the jelutong.[243] Severe and careless tapping methods by these natives has resulted in the death of many trees, especially because the injured portions were left exposed to attack by white ants and borers. Efforts to prevent the extermination of the trees has been without avail due to the remoteness of the districts in which the tree is found.

The method used by the plantation companies is to cut a long V with a channel from the base of the V leading to a collecting cup. The production of the latex and the recovery of trees by this method are said to be good.[244]

The exudation coagulates like thick milk on the trees or in the collecting cups. The coagulated sap is either pulled from the bark or removed from the cups and taken to the "camp", water being added to prevent fermentation and to complete coagulation before reaching camp. At the camp the latex is further

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243 Joseph W. Vander Laan, Production of Gutta-Percha, Balata, Chicle, and Allied Gums, Trade Promotion Series No. 4, Bureau of Foreign and Domestic Commerce, 1927, p. 62.

244 Ibid., p. 62.

diluted with water and paraffin, stirred for two hours, left until morning, and then drained of the water. After repeated treatment with hot water and rolling, it is put into blocks for export.

A large tree yields 65 pounds of latex.[245] Trees of medium size can be tapped for about a year.

In the period between 1910-1915 this material was exploited as a source of rubber; but because the latex is full of gums, resins, and other impurities, and yields such a poor grade of rubber, this was soon rejected for possible development for rubber. Its principal use is as a substitute for chicle in gum manufacture,[246] finding a ready market in the United States for such use of the product. In 1935 the United States received shipments of jelutong reaching 12,643,496 pounds.[247]

Rubber. Rubber is one of the youngest of the world's major crops. The development of the rubber industry is one of the most spectacular developments of the twentieth century, growing from a primitive-gathering activity carried on by semi-savages in the equatorial rainforests, into one of the most important plantation industries of the tropics to furnish the material which goes into thousands of articles.

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245 Op. cit., p. 63.

246 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 164.

247 Ibid., p. 167.

Rubber is a solid which is contained in varying degrees in the milk or latex of a number of trees which are limited to the tropics. This latex occurs in tubes in the inner part of the bark of certain tropical trees and may be released by scarring the bark. Years of exploration and experiment have demonstrated that there is one outstanding rubber tree--Hevea brasiliensis; other trees in equatorial rainforests which are sources of rubber are Castilloa elastica which produces Panama Rubber or Caucho, Ficus elastica which is the source of Assam Rubber, and Funtumia elastica from which is obtained Lagos Silk Rubber.

Para Rubber. The Para rubber tree (Hevea brasiliensis) is the source of 90 to 95 per cent of the rubber produced throughout the world.[248] From this species of tree comes the best grade of rubber. The Para or Hevea tree which grows to a height of 60 feet is the most valuable of all rubber-producing plants because of its high yields and excellent quality of its rubber.

Hevea brasiliensis is a native of the hot damp forests of the Amazon and Orinoco Valleys, involving the parts of Brazil, Peru, Ecuador, Bolivia, and Colombia which lie within those valleys.

The Amazon Basin and to a slight extent the African tropics represented 99 per cent of the world's rubber production in 1906, declining after 1912, until in 1938 it represented only

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248 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 154.

2 per cent. Here the industry was based almost entirely on the exploitation of wild rubber trees. Since the Hevea tree is indigenous to the Amazon Basin, this region was naturally the first to fulfill the demands for rubber; the area maintained this position for a long time because the demand for rubber was so small that no one was particularly interested in trying to raise it; but with an everincreasing demand the supply of wild rubber was insufficient to satisfy it.

In northeastern Bolivia the highland Indians collected the wild product from the selva, and many communities at intermediate altitudes in the Yungas were all but abandoned in the rush for new profits; but the industry here was virtually eliminated by cheaper plantation methods of Sumatra, Malaya, and Java.

The province of Pará, Brazil was the center of rubber production in the days prior to plantation development though rubber was also obtained from along the tributaries of the Amazon as far inland as Peru, Bolivia, Venezuela, and the Guianas. The demand for rubber at first created a havoc in the Amazon Valley, rising to a mighty crescendo of speculation and wild spending in 1910, then declining to a very minor position among the world's producers after 1912.

Plantation rubber and "native production" resulted from successful attempts tc transplant the original rubber tree from its native habitat in Brazil to the Far East, and resulted in revoluticnizing the rubber industry. Today 98 per cent of the

world's rubber is produced on plantations and "native farms" in the Far East.

Western British Malaya produced just prior to the outbreak of World War II more than half the world's total rubber crop, producing most of it on the low coastal plains of well-drained soils back from the coastal swamps, with a few plantations on the hilly belt further inland.[249] Considerable quantities were also produced in the central belt of Sumatra, parts of western and southern Java, northern Borneo, the southern half of Ceylon, the southern part of India's west coast, southeastern Burma, and central Thailand.[250] These localities in the Far East have certain advantages for growing rubber on plantations: the environmental conditions are similar to that in which the Hevea tree is a native; there is an abundance of cheap, skilled labor; European capital and management is available; plantations have a high degree of accessibility since few need be more than a few miles from the coast or port because of their insular character.

Up to 1906, about 99 per cent of the rubber was a product of the wild forests of the Amazon Valley, because then the demand was small; it was nothing more than a primitive forest-gathering activity carried on by natives in a region of the

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249 Clarence F. Jones, Economic Geography, The Macmillan Company 1941, p. 159.

250 Ibid., p. 159 (fig. 93).

Tropical Rainy climate. The rubber was gathered by workers almost literally buried in the forest. These workers were recruited in Belem or Manaos by owners of tracts of land who loaned the workers funds with which to buy not only essential items of equipment but also tinned food. Each family of workers was then transported to a spot on the river bank accessible to the launch of the owner and there they were deposited and left to build rude shelters for homes. From each isolated camp the gatherer cut for himself a path or estrada through the forest, leading to perhaps two hundred rubber trees. The latex tapped from these trees was brought to his camp and there formed into solid rubber balls by smoking over a slow fire. Under these conditions there could be no supervision of the tapping methods and no care of trees to insure a continous production.

At intervals the owner's launch would make its appearance, pick up the product, and leave supplies for which the worker was never quite able to pay, and thus always remained in debt.

The rubber industry in the Amazon forests faced serious handicaps. Rubber trees grew singly and sometimes far apart, so that an individual latex gatherer found it impossible to tap many trees. The unhealthful climate resulted in labor being victimized by malaria, dysentery, and yellow fever. Native labor was inefficient, limited, and unintelligent. The great distances from the coast to the interior where the trees were

tapped resulted in time-consuming transportation and expense.

Brazil's system of destructive exploitation of rubber collapsed when trees raised from Hevea seeds collected in the Tapajos Valley by Sir Henry Wickham were successfully planted in plantations of Ceylon, and later in Malay and Sumatra.

At present 98 per cent of the world's rubber is produced on commercial plantations[251] owned and operated largely by Europeans. The cost of plantation rubber is only a fraction of the cost of collecting the wild product. While the yield of wild rubber trees is about three pounds per tree, those of the Malay variety yield as much as 10 to 17 pounds per tree. In the Amazon one man can scarcely attend more than 200 trees, while in a rubber plantation one worker takes care of more than 500. In the Amazon there can be no supervision of tapping methods and no care of trees; in a plantation trees are given attention by experts to guarantee maximum yields. In the wild forests the workers are exposed to all dangers of malaria and tropical diseases as well as hardships of life within the forest; on the plantations the workers are carefully housed, given medical attention, and fed a carefully regulated diet. Finally, close to the plantations of Malaya and Sumatra are densely populated lands where large numbers of efficient workers can easi-

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251 Ray H. Whitbeck and Vernon C. Finch, Economic Geography: A Regional Survey, McGraw-Hill Cook Company, Inc., 1941. p. 378.

ily be recruited; no such source of labor is available under existing conditions in the Amazon Valley.

"Native farms" have been introduced by natives near many plantation areas. These consist of many rubber tree planted by natives in small plots near their homes and thereafter tapped and sold by them directly. Native production eliminates great plantation overhead and the cost of highly paid supervisors. When rubber prices are low, the natives cease tapping the trees and continue to make a living by raising subsistence crops.

The Ford Company has carried on experiments in establishing rubber plantations in the Amazon Valley and to a small extent in Liberia in Africa. In 1927 in the northern section of Brazil, the Companhia Ford Industrial do Brasil purchased a tract of land including some 2,500,000 acres along the right bank of theRio Tapajos, about 135 miles upstream from the Amazon--an area becoming known as Fordlandia. About 8400 acres of rubber trees were planted and then a number of unexpected difficulties arose; diseases attacked the plantation of Hevea trees; the land was found to be so hilly that soil erosion became critical and the use of machinery was difficult.

In 1934 a part of the original concession was exchanged with the state of Para for a new tract of land, including about 600,000 acres, only 30 miles up the Tapajos from Santarem--the new tract being called Belterra. Up to April, 1939, about

12,500 acres were planted with rubber.[252] Here the land is more nearly level and this permits more efficient use of machinery and better agricultural practices. The selection of disease resistant stock and grafting of high yielding Malayan varieties on hardy roots of the indigenous trees are expected to overcome technical problems of rubber-growing in the Amazon.

The Ford project remains essentially an experiment. Rubber has not been produced commercially there so far, though some of the plantations have been tapped since 1937. Even at full production the region could scarcely account for more than a fraction of the world's production.

The climatic requirements are such that the Hevea tree can be grown only within the belt of rainy tropics, and then profitably only in certain restricted areas. For best growth of the Hevea tree temperatures must be uniformly high, 80° F. or more, with no month having less than 70° F.[253] In addition to continuous warmth, much rainfall accompanied by high humidity of 75 to 80 per cent is needed--100 inches or more annually,[254] and not less than two or three inches in any one month. It is preferable that the rainfall occur in the afternoon in order that morning tapping and gathering be not interrupted.[255] A

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252 Preston James, Latin America, Lothrop, Lee and Shepard Co., 1942, p. 557.

253 Clarence F. Jones, Economic Geography, The Macmillan Com- 1941, p. 158.

254 Ibid., p. 157.

255 Ibid., p. 158.

pronounced dry season is decidely unfavorable and cannot be withstood by the Hevea tree; it interrupts the flow of latex. Therefore, the longer the rainy season the longer the season of latex flow, and so a more economical use of the labor supply results. Gently sloping land is essential for the prevention of water-logging and overdevelopment of the soils; it also decreases disease, and in addition provides easier transportation. Where these slopes face the prevailing winds, they secure rainfall more regularly at all seasons than do flat areas or lowlands.[256]

The Hevea tree grows on poor as well as fertile soils; but deep loam, loose and well-drained, is needed to allow the tap roots to grow ten feet deep.

Location of plantation or groves near the seacoast is an asset, for it gives sea breezes which afford more pleasant and healthful conditions than do places farther inland.[257]

A relative abundance of skilled, low-priced labor is a necessity. The tapping of the trees is not only laborious, but one which requires considerable skill and efficiency. Because each tree must be tapped every other day, the industry requires an abundant supply of low-priced labor. In the plantations of the Far East the Chinese and southeastern Asiatics are the best

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256 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 158.

257 Ibid., p. 158.

workers, being far superior to the Brazilian Indian or mestizos in the amount of work they can do and their skillfulness--a factor of great significance--for carelessness in tapping often kills the tree. Hence, plantations have been successful only in those sections of the Far East where an ample supply of cheap, efficient labor is available or can readily be introduced. Thus, by the time of the outbreak of the present war British Malaya and the East Indies had risen to the position of the largest rubber producer of the world.

Plantations are most profitable when located either within a few miles of the coast or inland along a railroad so that convenient and cheap transportation to the coast is possible. In neither case is the transportation haul more than a few miles to the coast. Rubber from the Amazon Basin often must be hauled a thousand miles before the coast is reached. Thus, the favorable location of the plantations with reference to the coasts in the Far East is one of their great geographic advantages. Also to be considered in the favor of the East Indian plantations is the position of this region on the great trade route from the Orient to western Europe and the United States. In the pre-war days when there was ample space for rubber, cargo transportation in boats using this great trade route was very cheap.

Hevea trees are propagated either from seed or by budding. Seeds from Hevea trees of superior performance usually are used

for the former method; but budding onto seedlings of Hevea trees is done on more advanced plantations. After the second year of growth, the trees are set out in cleared forest jungle land. An established plantation usually contains from twenty to thirty trees to the acre.

In five to six years the Hevea trees yield their first latex, from five to ten ounces per tree. Commercial bearing is reached by the eighth to tenth years when the trees yield from two to three pounds of latex per tree. When the tree reaches fifteen to twenty-five years of age, the yield may be four to ten pounds. The trees can be tapped regularly throughout the year except for a few weeks during the less rainy season. As much as 350 to 400 pounds of latex may be obtained from an acre of plantation Hevea trees.

When the trees reach a diameter of six inches (in about six years), the tree is ready for tapping, usually when the seed capsules form and explode. The work on rubber plantations starts at daylight since the best flow is between 5:00 A.M. and 10:00 A.M. Many tapping systems are used, but the basic principle is to get as much latex as possible with as little injury to the bark and as little weakening of the tree's vitality. The "half-herring bone" method is common: on the first day oblique cuts are made about one-half the tree's circumference, all leading to a central vertical cut at the lower end of which a metal, porcelain, or glass cup is fastened to catch the cream

like white latex; on the second day after the first, a thin shaving of about one-thirty-second inch is sliced from the lower edge of the cut and this may be repeated every two to three days till the scarf of the cut is two inches wide; then a new set of cuts is begun on the opposite side of the tree. The tapping begins low down on the trunk, each subsequent area of cuts being made a foot higher than previous ones on the same side. A skilled tapper makes 1000 to 1500 cuts a day, depending partly on whether there are to be two, three, or four cuts to a tree.

The flow of latex lasts about one-half hour, flowing at the rate of two drops per second: then the tapper or his assistant begins collecting the latex. A 1000 acre plantation requires 200 pair of hands in the field for tapping and collecting. One man can tap and gather latex from 400 trees in six hours in the morning. The collections are assembled in large cans and transported to a central factory on the plantation.

In the plantation factory the latex, after straining, is poured into large tanks where a coagulating substance produces a spongy mass of rubber within an hour; this mass is put into a rolling machine from which it issues as a ribbon several inches wide and about an eighth of an inch thick. The rubber is then cured and packed for shipment. The United States, however, has shown a preference for much liquid latex; this contains ammonia, which is added to preserve the latex and prevent coagu-

lation.[258]

Until the present hostilities interfered with the rubber trade of the world, the countries of southeastern Asia--British Malaya, Netherland Indies, Ceylon, British Borneo, and Indo-China--supplied 98 per cent of the rubber exports.[259] The rubber importing countries were mainly the United States and the countries of western Europe--particularly the United Kingdom, Germany, and France.[260] The large number of automobiles in the United States and west central Europe accounted for the great rubber imports of these two regions. Rubber goes into thousands of articles, chiefly tires and tubes, wearing apparel, surgical work, boots, overshoes, and rubbers.

The great development of the rubber-growing industry has not been without its drawbacks, however. Overproduction has seriously affected the industry financially in recent years and many attempts have been made at some sort of regulation. Then, too, the recent successful development of synthetic rubber further tends to jeopardize the natural rubber industry, for the new product is superior to the old in many ways.

Panama Rubber (Caucho). Panama rubber or caucho, the prod-

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258 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 156.

259 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 162 (fig. 96).

260 Ibid., p. 162 (fig. 96).

duct of the Castilloa elastica, is the most important among the numerous other sources of rubber after the Hevea brasiliensis. The tall Castilloa tree is a native of Mexico and Central America.[261] It has served as a source of rubber since 1875.

Castilloa elastica is now being extensively cultivated in Central America and southern Mexico under plantation conditions, but it cannot successfully compete elsewhere with Hevea brasiliensis (Para rubber). Outside Central America it is found in the hot humid forests of northern South America. Panama rubber is one of the many products of the tropical rainforests of the Pacific Margin and Atrato Valley of Colombia.[262] The humid forest areas of northern Colombia also support many Castilloa trees.[263] Caucho or Panama rubber constitutes the only Ecuadorian rubber of commercial importance, occurring in the forests of eastern Ecuador.[264] From this region the rubber which is gathered from this tree leaves by way of the Amazon River, and Ecuador gets no credit for it. The district of major development in South America lies in the Amazon Basin on the dry uplands on the western slopes of the Andes (Montaña district), involving the upper Yavari, Juruá, and Purús Rivers; and also

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261 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 157.

262 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 548.

263 Ibid., p. 563.

264 Ibid., p. 526.

on the territory to the north and south of the lower Amazon in Brazil.[265]

The Castilloa tree grows in deep loamy soil on high ground (above the flood zone of rivers).[266] It requires the climatic conditions of the Tropical Rainy climate--high yearly rainfall and temperatures always above 60° F.[267] When young, the trees must have shade for protection from the strong rays of the sun.

The inferiority of caucho made ruthless methods of exploitation the rule. Formerly the trees were cut down in order to obtain the largest possible yield of latex. This wasteful method resulted in virtual extermination of the species over large areas. Today more conservative methods are in use. The trees are tapped when eight to ten years of age, and then yield up to 50 pounds.[268] The latex is coagulated with plant juices, alum, and by boiling or exposure to the air. The crude rubber is shipped in flat cakes.

Production depends entirely upon market prices, for the output represents only the gatherings by unorganized natives.

When prices are high, the negro or Indian bestirs himself to activity, but when prices fall, he readily lapses into his customary state of indolence.

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265 Op. cit., p. 503.

266 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 157.

267 Ibid., p. 157.

268 Ibid., p. 158.

Assam Rubber. Assam rubber, or India rubber as it is more familiarly called, is obtained from Ficus elastica, a tree native of northern India and Malaya.[269] The tree grows to great heights, developing huge buttresses or prop roots. The roots as well as the stem are tapped.

Ficus elastica requires a hot humid climate with a large amount of rainfall.[270] The trees are tapped and the latex is allowed to drip onto bamboo mats where it coagulates. Then the crude rubber is scraped off, cleaned, and dried. So very wasteful have been the native methods of tapping the wild trees that the tree is now cultivated to some extent in the Far EAst. The yield per tree is low and the trees do not mature until about fifty years of age.[271]

Assam rubber is of low grade and is of little commercial importance at the present time.[272]

Lagos Silk Rubber. Lagos silk rubber comes from Funtumia elastica, a large tree which grows in tropical West Africa.[273] After its discovery in 1894, it was immediately exploited by

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269 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 159.

270 Ibid., p. 159.

271 Ibid., p. 159.

272 Ibid., p. 159.

273 Ibid., p. 159.

such wasteful methods that it has been nearly exterminated. In 1898 over 6,000,000 pounds were exported. The tree is now being cultivated and attempts are being made to reestablish the industry.

MASTICATORIES

The Tropical Rainy climate is the only one which produces tree crops which are cultivated or collected chiefly for use as masticatories. The two outstanding tree crops having such importance are the areca or betel-nut and the cola (kola) nut.

Areca or Betel-Nut. Probably more people chew areca or betel-nuts than any other masticatory.[274] The number has been estimated at two hundred million people[275]--one-tenth of the entire human family. The habit is indulged in from Réunion and Zanzibar to India, Ceylon, southeastern China, the East Indies, the Philippines, and some islands in Oceania. Over 50,000 tons of this nut are used annually for chewing purposes alone.[276]

Areca or betel-nuts are the seeds of the fruit of a palm (Areca catechu).[277] The fruit is a fibrous, one-seeded drupe about the size and shape of a hen's egg, smooth, orange or scarlet in color, the fibrous husk being about one-half inch thick.

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274 Op. cit., p. 286.

275 Ibid., p. 286.

276 Ibid., p. 286.

277 Alphonse De Candolle, Origin of Cultivated Plants, Sir Isaac Pitman and Sons, Ltd., p. 427.

Within the outer fibrous rind is the seed commonly called areca or betel-nut.

It is believed that the betel-nut palm is a native of the Malay Archipelago, principally Sumatra.[278] Its cultivation by Malayan peoples considerably antedates the Christian Era. The only places where the betel or areca palm is found growing wild is in Sumatra and the Philippine Islands; and here it is part of a forest-collecting industry. The betel-nut palm is now largely cultivated in the other tropical parts of the East. Ceylon has no less than 70,000 acres in these palm trees on that island alone.[279] Other regions of production include India, Cochin-China, Thailand, the Sunda Islands, and Malaya. The natives of these localities plant and produce the nuts on a small scale individually.

All the betel-nut producing areas are restricted to the Tropical Rainy climate of southeastern Asia. Here the palm grows over the low country and in the hills up to an elevation of between 2000 and 3000 feet above sea level.[280] The rainfall needs to be high, and should be as well-distributed as possible. The lay of the land should be moderate for best yields. The palm flourishes best in sandy soil. Like all palms, the betel

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278 Op. cit., p. 428.

279 Otis W. Barrett, Tropical Crops, The Macmillan Company, 1938, p. 396.

280 John Ferguson, All About the Areca Palm, A. M. and J. Ferguson, 1897, p. 9.

stands wind well.

When the palm is cultivated, the native growers crowd 4000 to 5000 of them into an acre of cleared forest land. A betel-nut palm requires six years to come into full bearing.[281] Most of these palms yield 200 to 250 fruits per year--a million to the acre--a tremendous crop.[282] The fruits are gathered annually between August and November before they are quite ripe, and they are deprived of their husks. The spring is considered the best cropping season by some authorities, particularly January, but the crop extends pretty well more or less throughout the year.[283] The crop can be picked for local sale three-fourths or fully ripe.[284]

Preparation of the "nuts" for market involves boiling in water, cutting them up into slices, and drying in the sun, by which treatment the slices assume a dark brown or black color.

The chief use for which the betel-nuts are cultivated and collected is for use as a masticatory. Ninety-nine per cent of the nuts produced are chewed with lime wrapped in the betel pepper leaf,by the natives in the region from Indo-China through the Philippines and all the Malayan countries to western India; here it forms a considerable article of trade.[285] Ceylon ex-

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281 Op. cit., p. 9.

282 Otis W. Barrett, Tropical Crops, The Macmillan Company, 1938, p. 396.

283 Op. cit., p. 10.

284 Ibid., p. 10.

285 Op. cit., p. 396.

ports a surplus to India, some 7000 or more tons annually, a comparatively small amount in relation to its production.[286]

For use as a masticatory a small piece is wrapped up in a leaf of the betel-vine with a pellet of shell lime, and sometimes cloves, tamarinds, or other flavoring materials. When chewed, it forms an agreeable stimulant which produced a flow of saliva, and blackens the teeth to the satisfaction of the natives.

The United States imports small quantities of betel-nuts (90,835 pounds in 1935).[287] In this country the nuts are used in the preparation of medicines and catechu, a decoction of the nut which is used in tanning preparations and for dyeing the browns.

Cola (Kola) Nuts. The seeds of the cola tree (Cola acuminata)[288] are known as cola or kola nuts in commerce, and are used extensively in many parts of tropical Africa as a masticatory. For this reason the cola nut is referred to popularly as "the chewing gum of Africa".

The cola seeds are produced in the large, woody, brownish-yellow pods which are borne in clusters of three to five at the

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286 Otis W. Barrett, Tropical Crops, The Macmillan Company, 1938, p. 396.

287 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 278.

288 Op. cit., p. 394.

ends of small branches of a fairly tall tropical tree referred to as the cola tree. Each pod contains anywhere from two to fifteen irregularly flattened, white, crimson, or purple seeds, (about one and one-half inches in diameter, and one-half to one inch in thickness at the middle), enclosed in a watery, sweetish pulp within the woody pod. The fresh seeds have the odor of nutmeg, but after drying they become bitter and turn to reddish-brown in color.

The cola tree is a native of the forests of tropical West Africa, in the region south of 7° 30" latitude.[289] This tree grows wild, but is also cultivated to a large extent by the natives in the region of West Africa, stretching five hundred miles from the coast into the interior between Sierra Leone and Lower Guinea, at the edge of the tropical forest. Within that area the Gold Coast and the hinterland of Liberia are important producers of that tree.[290] Outside Africa the cola tree has been grown with considerable success in Jamaica, and in one or two places in the tropical Brazilian forests of northern South America.[291] If public demand should call for it on a larger scale, it could probably be grown extensively and with good profit almost anywhere in tropical America. It has been introduced into India and other parts of tropical Asia, but the pro-

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289 Op. cit., p. 394.
290 Ibid., p. 395.
291 Ibid., p. 395.

duction there is not yet large because of the small demand for these "nuts" there.

Production of the cola nuts is largely within regions of the Tropical Rainy type of climate, particularly along the edge of the tropical forests where there is a season of less rainfall in contrast to a season of high rainfall. It is grown in some limited parts of the world where the Tropical Monsoon climate prevails.

At present the industry is in the hands of natives who care for a few hundred scattered trees--which are only partially cultivated--on the outskirts of their barbarian villages. If the demand arises, there will eventuate regular groves of heavy yielding trees under native care.

The trees fruit semi-annually, and the pods are gathered by the natives twice a year--in October and November, and again in May and June. The pods resemble cacao pods, but are borne in clusters of three to five at the end of small branches, instead of on "button", on the trunk and large branches.[292] After the pods have been gathered, the cola seeds or "nuts" are removed from the pulp and wrapped carefully in leaves which resemble lotus leaves. These are frequently moistened to prevent the seeds from drying, as well as to induce fermentation. Then

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292 Otis W. Barrett, Tropical Crops, The Macmillan Company, 1938, p. 394.

from the hinterland thousands of porters carry, either on their heads or backs, forty, sixty, or seventy pound loads of these carefully wrapped seeds over a network of footpaths which lead down to the coast for export. Railways are used where they exist.

For every pound of cola "nuts" exported a hundred weight is probably absorbed in the vast realms of the Sudan. These are in great demand by the natives as food, and for chewing as a stimulant. Scarcely an individual exists in the triangle formed by Gambier, Abyssinia, and the Congo who does not use it if he can obtain it.[293] Cola nuts are a comparatively expensive commodity in Africa; starting on the west coast at the price of one hundred seeds per cent, its value goes up rapidly as one progresses toward the interior, until in the eastern Sudan a white cola seed may cost the equivalent of ten cents' worth of goods in barter.[294]

In the United States and Europe the dried cola seeds are imported, powdered, and used in making an extract which forms an ingredient in many beverages. The European markets absorb yearly some 10,000 tons of cola nuts; 2800 tons are imported annually from the hinterland of Liberia, and nearly 8000 tons from the Gold Coast.[295] The United States has yet to learn to

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293 Otis W. Barrett, Tropical Crops, The Macmillan Company, 1938, p. 394.

294 Ibid., p. 395.

295 Ibid., p. 395.

use cola "nuts" to a greater extent. Its use in this country is limited to various soft drinks, principally coca-cola. Because of its stimulating properties it is used in medicines to prevent fatigue.

NUTS (EDIBLE)

The number of edible nuts produced by trees in the Tropical Rainy climate is large. Only a few, however, are known to people outside the tropical rainforests. Five of these enter annually into commerce to add to the world's food supply: Brazil nuts, cashew nuts, coconuts, paradise nuts, and pili nuts.

Brazil Nuts (Castanhas). The Brazil nut is one of the important tropical nuts entering world trade. Ranking next to the rubber industry in the vast expanse of the tropical rainforests of the Amazon Basin is the Brazil-nut industry.[296] These delicious nuts--known also by such names as castanhas, cream nuts, and "nigger toes"--are obtained from the Brazil nut tree (Bertholletia excelsa), a rough-barked giant native to the equatorial rainforests of the Amazon and Orinoco Valleys of South America. Brazil nuts are so called because the trees bearing them are found almost exclusively in Brazil. In Brazil, however, the name given to them is "castanha do Para" (Para chestnut).

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296 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 508.

Each Bertholletia excelsa bears from eighteen to twenty-four hard, brown, spherical, woody fruits or capsules, from four to six inches in diameter, nearly as large as a boy's head. Within each capsule are fifteen to thirty triangular seeds or nuts, with a hard bony covering; these triangular nuts are the Brazil nuts of commerce.

Most of the Brazil nuts at present are obtained from trees growing wild in forests on the well-drained, drier uplands of the Amazon River Valley and the tributaries of the Amazon, above the flood zone. This includes practically all the lower Amazon Basin, especially the land north of the main river which borders the Rio Trombetas, and that part of the basin of the upper Amazon (Solinoes) as far as the upper Beni in the Madeira system, at about 13° South Latitude, and the eastern section of the Acre Territory.[297] From here the castanha territory extends northward, following the highlands of the various tributaries of the Amazon. Castanha trees abound in the Rio Negro and its chief tributary, the Rio Branco, and in the region above Manaos on both sides of the Solinoes for about half the distance from Manaos to the Peruvian border.[298]

The states of Amazonas and Para in Brazil furnish the

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297 A. Ogden Pierrot, The Brazil-Nut or Castanha Industry, Trade Information Bulletin No. 259, Bureau of Foreign and Domestic Commerce, 1924, p. 3.

298 Ibid., p. 3.

greatest quantities of nuts for northern markets.[299] In the state of Amazonas the greater part of the castanhas comes from the regions of the Rios Negro, Solinoes, Purua, Medeira, and Maues. In the state of Para about 60 per cent is produced in the three municipal districts of Obidos, Alemquer, and Almeirim --all on the north side of the Amazon.

On the "tierra firme" of the eastern lowlands of Bolivia, on the higher and fairly well-drained soils, the castanha trees are present, towering above all adjacent trees.[300] This tree does not occur in eastern Peru.[301]

In South America the trees are never cultivated for they may be encountered in large groves. The entire output of over 16,000 tons is obtained wholly from the wild trees on lands which are the property of the state. Brazil nuts are now being produced as a plantation product in the Far East--in Ceylon and the Federated Malay States--and this threatens the forest-gathering activity of Brazil. Plantations of this tree were set out on an experimental basis in British Malaya. Little effort has been made to develop plantations in South America. Great inaccessible castanha areas have yet to be exploited and these have drawn the attention of the Amazonian proprietors of land away from planting the trees.[302]

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299 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 502.
300 Ibid., p. 270.
301 Op. cit., p. 12.
302 Ibid., p. 12.

Bertholletia excelsa requires high temperatures and high rainfall throughout the year, a condition which causes it to make its home within the tropical rainforests of the Tropical Rainy climate. However, the tree needs fairly well-drained soils, so that its presence is restricted to the higher lands or "tierra firme"--high areas well above the flood zone--in the tropical lowlands of the Amazon River and its tributaries. Plenty of cheap labor is required for gathering these nuts in order to be able to place them on the markets at reasonable prices. Numerous insect pests and diseases prevail in this climatic type and handicap the workers, especially in South America. Those trees in areas near the rivers are exploited, their location facilitating transportation.

In the Amazon Valley where no cultivation is attempted, native workers, or castanheiros (gatherers), are granted free access to the public lands if they wish to utilize or develop the forest resources, and they are free to collect the nuts at will.[303] Castanheiros enter the forests after the capsules have dropped from the trees. The period of gathering begins in November and lasts until June, the greater part of the crop falling from January to March.[304] Regions where the nuts commence falling in November have the advantage of reaching the northern

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303 Op. cit., p. 6.

304 Ibid., p. 7.

markets in time for the Christmas season and so are able to secure higher prices for their nuts. The castanha nuts fall during the rainy season. Following the rainier season the rubber trees are idle, and a maximum amount of water in the rivers enables the castanheiros to go up even the small rivers and penetrate the forests by canoe navigation at their farthest limit.

When the castanhas reach maturity, the heavy rains and winds cause the large round hulls to fall to the ground. Because the work of gathering these from under the trees is perilous, they are gathered when there is little or no breeze. Falling capsules weighing three to four pounds each account for this precaution. The actual gathering of these capsules is simple; they are thrown out from under the trees, gathered in baskets, and carried on the backs of the gatherer to a temporary hut set up in the vicinity. During days with strong winds, the castanheiro spends his time breaking open the outside hulls with machetes and extracting the nuts contained within. These are carried via streams to the shipping ports. Occasionally the entire capsule is taken directly to the shipping ports where the enclosed triangular-shaped nuts are freed.

Only a small part of the entire crop of Brazil nuts is gathered and sent to market mainly because of the difficulty in getting the nuts from the inland forests which in many cases are some distance from navigable rivers. As a result many of these nuts go to waste each year.

The average daily production per man is one and one-half barricas (a barrica being 120 quarts). The average production per man during the entire gathering season never exceeds seventy barricas (8400 quarts).[305]

Sacks of Brazil nuts are loaded on steamers principally at Manaos and Belem (Para) to be sent to the United States and Europe where they are looked upon as a luxury food. The United States imported 15,642 tons of these nuts in 1935.[306] The demand for this luxury food in the major markets of the world is relatively limited; this is caused partly by the fact that Brazil nuts are looked upon as a relatively expensive delicacy.

There has been a distinct relationship of Brazil nut production and the rubber industry in South America. During the wild-rubber boom, the natives left nut-gathering, because they could make more money collecting wild rubber. When the wild-rubber boom collapsed in 1912, the natives again turned to collecting Brazil nuts and found ready markets for them in the temperate regions. The low price of plantation rubber forced people to gather other forest products which had not then been produced on plantations. Now Brazil nuts play a major part in Brazilian trade, being next in importance to rubber-collecting

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305 A. Ogden Pierrot, The Brazil-Nut and the Castanha Industry, Trade Information Bulletin No. 259, Bureau of Foreign and Domestic Commerce, 1924, p. 9.

306 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 376.

in the tropical forests of the Amazon Basin.

Cashew Nuts. Within the last thirty years the cashew nut has been fast gaining in popularity in the United States, being almost unknown to Americans prior to that time. The cashew is a curved, inch-long, kidney-shaped seed or nut which grows on the outside, at the distal end of the cashew "apple", the fruit of the cashew tree (Anacardium occidentale). The nut is more important in commerce than is the fruit.

This tropical American tree is considered indigenous to the campos and dunes of the lower Amazon region, and the northern Brazilian coast.[307] It is now extensively cultivated in many tropical portions of the world. It is common on the coastal lowlands of the mainland of tropical America from Mexico down to Peru and Brazil. Vast stands, scarcely touched as yet, occur in northeastern Brazil[308] and thousands of tons of kernels could be exported from this region. In the United States the culture of this tree is limited to the coast of Florida, south of Palm Beach and Punta Gorda. In California experiments up to the present have indicated that the climate is not warm enough for it. The tree is abundant in the West Indies. In Mexico and Central America the cashew is common on the seacoast.[309]

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307 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 148.

308 Otis W. Barrett, Tropical Crops, The Macmillan Company, 1938, p. 331.

309 Op. cit., p. 149.

In Africa thousands of acres of the cashew tree are found in West Africa, Mozambique, and the nearby island of Madagascar.[310] In southern India the tree has been naturalized in the coastal forests.[311] Other regions of production include the Malay Peninsula and the islands of the East Indies.

The cashew tree is not particular in regard to the soil on which it grows; it can be grown successfully on any soil. It is, however, intolerant of frost and so can only be cultivated in regions where temperatures much below freezing are rarely experienced. Even within the tropics the tree is rarely found at elevations higher than three hundred feet because above that altitude the climate appears to be too cool for it.

The trees begin to bear fruit in the second or third year, and continue to bear until the fifteenth year at which stage the trees exude in large quantities a gummy substance similar in character to gum arabic, and then die. In Brazil the fruit ripens and is gathered from November to February. In India the ripening season commences in March.

In many regions the nut is more extensively used than the apple or fleshy portion. In tropical regions the nuts are eaten raw or roasted; when imported they are commonly roasted and salted, or used in confectionery.

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310 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 149.

311 Ibid., p. 149.

Each year between 2,500,000 and 3,000,000 pounds of cashew nuts are exported from South America alone, the bulk going to British destinations. This represents only about 5 per cent of the possible South American output. Since 1900, however, imports of cashews into the United States have been steadily increasing, by 1935 having climbed to 22,376,432 pounds.[312]

Coconuts. Few people consume coconuts as edible nuts, that is, for the nut-meat itself; instead, the fruit is more important as one of the principal sources of vegetable fats.

Whole coconuts are not of any great importance in international trade because they are too bulky and of too low value to stand long distance transportation.[313] The food market in the United States is, however, provided with a limited number of these nuts for direct eating purposes, mainly from the nearby Caribbean lands. The other coconut product used as food is the shredded, dessicated meat which belongs in the luxury class and is used mostly in cakes, pastries, and confectionery.

Imports of coconuts and coconut meat amounted to over 50,000 tons in 1935.[314]

For a detailed account and discussion of the coconut palm

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312 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 376.

313 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 414.

314 Op. cit., p. 376.

(Cocos nucifera) which produces these nuts, see pages 206-216.

Paradise Nuts. The paradise nut is similar to the Brazil nut in that it consists of many small nuts which develop in a large ourico, just as the Brazil nut does, but in shape and taste they differ, being considered by many a little finer in flavor than the Brazil nut.[315]

This nut is known as "sapucaia" in Brazil and "paradise nut" in the United States.[316] It is not very well known in the United States because of the small quantity bought by this country from South America.

Unlike the castanha tree, the sapucaia tree (Lecythsis paraensis) is almost always found on the low level land of the lower Amazon.[317] Within the lower Amazon Basin, especially on the alluvial areas, small plantations of this tree have been established with very successful results. Because of the fact that this nut realizes a price usually double that of castanhas in the northern markets, because the tree begins to bear at an early age (fifth to sixth years), and because there is always a ready market in the north for the small amounts which so far have been produced, it is reasonable to suppose that plantation development would be an attractive enterprise.

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315 Forrest Crissey, The Story of Foods, Rand McNally and Company, 1917, p. 419.

316 A. Ogden Pierrot, The Brazil-Nut or Castanha Industry, Trade Information Bulletin No. 259, Bureau of Foreign and Domestic Commerce, 1924, p. 13.

317 Ibid., p. 13.

Thus far only small supplies from the wild forests have been available for export. The chief reason given for this is that many are devoured by the monkeys who dwell in the forests where these trees grow. This nut which grows in a large pod has a small "cap" at one end. A gas which forms in the pod after it has fallen to the ground forces the "cap" out with a loud report. This attracts the monkeys who then search for the nuts in the dense undergrowth, where they have been "blown" by the force of the explosion.[318]

The methods employed in gathering and marketing the paradise nuts are the same as for the Brazil nut[319].(See page 193). All of these nuts which are exported proceed from Para, Brazil.

In addition to its use as a food product, the sapucaia produces a yellow oil, which, when fresh, is used as olive oil. The principal use of the oil is in the manufacture of a high-grade, white, aromatic soap.

Pili Nuts. Often found in mixed nuts are pili nuts, the seeds of an edible plum-like fruit of Canarium ovatum, a tree native to the tropical rainforests of southeastern Asia, the East Indies, and the Philippine Islands.

Popularly called Javanese almonds, the pili nuts are high-

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318 Forrest Crissey, The Story of Foods, Rand McNally and Company, 1917, p. 420.

319 A. Ogden Pierrot, The Brazil-Nut or Castanha Industry, Trade Information Bulletin No. 259, Bureau of Foreign and Domestic Commerce, 1924, p. 14.

ly appreciated in the Orient, where they are consumed in large quantities, raw or roasted. In appearance they are spindle-shaped, and triangular in cross section, with a very thick, hard shell.

In tropical regions a fatty oil is expressed from these nuts and is used for eating and in lamps.

OILS AND WAXES

The number of oils furnished by tree crops of the Tropical Rainy climate is indeed a lengthy one. However, only those which are of some commercial importance will be treated. All the oils have been divided in this discussion into two major groups: the fixed oils and the volatile (essential) oils.

The fixed oils are those which do not evaporate upon exposure to the air; and they are generally obtained by mechanical means, especially by the application of pressure, from the wood, seeds, fruit, and leaves of trees. Among the principal fixed oils obtained from tree crops of this climatic regime are babassu-nut oil, Borneo tallow, candle-nut oil, carapa fat, coconut oil, cocoa-butter, cohune-nut oil, kapok oil, mowra fat, nutmeg butter, palm oil and palm kernel oil, pili-nut oil, and sapucaia oil. These fixed oils are used in paints, varnishes, and medicines; in cooking and soapmaking; for lubrication, illumination, and table use.

The volatile oils, because they are essences extracted from their various sources by distillation, are sometimes called

essential oils. They evaporate quickly and will not change into soaps. Their sources are the flowers, fruits, spices, and sap of trees. Chief among those obtained from tropical rainforest areas are champaca oil, oil of bay, oils of cinnamon and cassia, oil of cloves, oil of copaiva, oil of pimento, nutmeg oil, sandalwood oil, and ylang-ylang. These oils are used in perfumery, flavoring, medicines, and paints.

Only one wax, raffia wax--and this of minor importance--is produced within this climatic zone.

Fixed Oils

Babassu-Nut Oil. The majestic Orbignya speciosa[320] bears large hanging clusters of nut-fruits, known by name as babassu-nuts, which yield about 66 per cent oil.[321] The nut is about the size and shape of a small pointed lemon and has about two or three kernels; each bunch contains about 1250 of these nuts, and each tree annually produces four to five of these bunches.

The babassu-nut palm is a native of northeastern Brazil. It grows wild in vast and almost pure stands in the zone of transition between the rainforest and savannas and scrub forest of the northeastern portion of Brazil; this region involves the lower Amazon Basin just south of Para, reaching from Bahias in-

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320 Anna G. E. Simmons, Babassu Nut, Economic Geography, XIX (1943), p. 279.

321 Otto Wilson, Oils, Fats, and Waxes in Latin America, Bulletin of the Pan American Union, LIV (1921), p. 344.

to Amazonas and stretches far equatorward across the plains and up the wide valley on to the slopes of the old, worn-down highlands in northern Minas Geraes, Goyaz, and Matto Grosso.[322] The growth is especially dense and extensive, chiefly in the states of Maranhão and Piaui.[323] The northern section of the entire area seems to be of the greatest significance with an approximate thirteen billion palms bearing an estimated thirteen trillion nuts.[324] The San-Luiz-Therezina area which is second to the Maranhão region is estimated to include hundreds of millions of trees.[325]

Orbignya speciosa thrives where there is a season of less rainfall in contrast to a season of heavy rain. As yet no plantations of this palm have been developed. The forest product is gathered and collected by natives whose methods are still rather primitive; it is done mainly by filling sacks with the gathered nuts. The native workers are temporarily recruited for the job; the babassu-nut gathering thus brings to such places as São Luiz at least a temporary increase of activity by attracting to it a stream of migrants.[326]

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322 Anna G. E. Simmons, Babassu Nut, Economic Geography, XIX (1943), p. 279.

323 Ibid., p. 279.

324 Ibid., p. 279

325 Ibid., p. 281.

326 Otis W. Barrett, Tropical Crops, The Macmillan Company, 1938, p. 291.

The tree is of such utility that it promises to give rise to an outstanding regional activity; it begins to bear fruit when eight to ten years of age; to the natives it furnishes food, shelter, clothing, fuel, and illuminant as well as serving to smoke-cure rubber;[327] commercially the nuts have greater possibilities as the source of a vegetable oil. From each bunch of nuts over six hundred grams of oil are extracted, and this kernel oil finds an importance in lubricants, fuels, medical salves, and perfuming medium in the manufacture of the finest grades of soaps. Babassu-nut oil serves as an excellent substitute for lard and olive oil in the human diet.[328]

It is thought by some that if the transportation facilities within the babassu-producing region were modernized, enough oil could be exported to supply the needs of the western hemisphere. At present large quantities go to waste because of the lack of modernized transportation.[329]

Most of the oil crushing mills are of the modern type; the large ones are located in Para and Therezina. In many of these women and children are employed in handcracking the hard nuts in preparation for oil extraction. Several thousand tons of these nuts are exported annually from Bahia, in Brazil, for oil

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327 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 510.

328 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 97.

329 Anna G. E. Simmons, Babassu Nut, Economic Geography, XIX (1943), p. 281.

extraction at the importing centers.[330]

It has only been recently that the United States became the chief consumer of babassu-nut oil.[331] In 1939 the United States and Chile procured the bulk, and Denmark followed in third place.[332] Prior to World War II large quantities were shipped to Germany.[333]

Borneo Tallow. The nut-fruits of several species of Shorea, especially Shorea aptera, yield a fat known as Borneo or Tangkawang tallow.[334] The trees are native to the tropical rainforests of the East Indies--Borneo, Sumatra, and Java.[335] From these forests the nuts are still obtained for the northern markets, being exported sometimes under the name of "Illipe nuts". The nuts are collected as they drop from the trees which grow wild, and the kernels, containing 50 to 70 per cent of the fat, are dried in the sun. From some of the nuts a fat is expressed by the natives by simple methods for their own use; some nuts are exported whole to Europe where the fat after extraction is employed in soap manufacture.

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330 Otto Wilson, Oils, Fats, and Waxes in Latin America, Bulletin of Pan American Union, LIV (1921), p. 344.

331 Anna G. E. Simmons, Babassu Nut, Economic Geography, XIX (1943), p. 281.

332 Ibid., p. 282.

333 Otis W. Barrett, Tropical Crops, The Macmillan Company, 1938, p. 291.

334 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 222.

335 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 94.

Candle-Nut Oil. The yellow-brown oil known as candle-nut oil is obtained from the hard-shelled seeds or "nuts" of the fruit of two species of Aleurites, Aleurites moluccana and A. triloba, the candleberry tree, which is a native of the Malay Pneninsula and the Pacific Islands (Polynesia), and is cultivated elsewhere in the East in regions of the Tropical Rainy climate.[336] The candleberry tree is thetropical sister of the tung tree of the North Temperate Zone.

The fruit is called candle-nut, and consists of two walnut-like, very oily seeds which when dry are so full of oil that they were used as "candles" by the natives throughout the Pacific Archipelago until kerosene came.[337] A bamboo splinter run through a dozen kernels and stuck into the floor or wall of the hut made a fair candle, hence, the name of the nut.[338] The nuts are still used for illumination in Hawaii and other Polynesian islands. Because it is a good drying oil, it is much used as a substitute for linseed oil in the making of paints, varnishes, lacquers, linoleum, and soft soap.[339]

Carapa Fat. Several species of trees of the genus Carapa

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336 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 214.

337 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 82.

338 Ibid., p. 329.

339 Op. cit., p. 214.

which are native of and found growing in the Tropical Rainy areas of the Guianas and Trinidad in South America,[340] West Africa, East Africa, India, Ceylon, and the Moluccas bear nuts, often called carop-nuts or crab-nuts, which are the source of an oil known as carapa fat, carop-oil, or crab-oil in commerce. The seeds of this nut are roughly tetrahedral in shape, with a reddish-brown shell containing a single kernel. The kernels contain 50 to 60 per cent of a thick white or yellow fat, which in Europe is used in making soaps.

In Trinidad the seeds are partially fermented and ground into a paste from which the oil readily exudes. South American natives use the oil from Carapa procera and C. guianensis to grease their skins and drive off insects. In East Africa, Ceylon, India, and the Moluccas Carapa moluccensis, in addition to its use as an embrocant, is used as an illuminant. Exports of this oil go chiefly to European markets for use in soap manufacture.[341]

Coconut Oil. This is one of the most extensively used of the fixed oils; its source is the coconut, one of the world's most important tree crops.

The coconut is the fruit of the coconut palm (Cocos nucifera) whose original home is unknown; but it is believed to be

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340 Clarence F. Jones, South America, Henry Holt and Company, 1930, pp. 53 and 667.

341 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 96.

a native of the tropical regions of the Malay Archipelago,[342] and has been carried to tropical and subtropical regions in all parts of the world, growing usually near the seashore, but also occurring at an altitude of 2000 feet.

This important fruit is a three-sided dry drupe. It consists of an outer fibrous cover enclosing a hard, woody nut lined with "meat". It is this "meat" which is valuable commercially because of its high content of vegetable oil.

The coconut palm is an inhabitant of the coasts of the tropics between 26° North Latitude and 22° South Latitude.[343] It occurs on little atolls in the Pacific; it fringes nearly all humid shores of islands and mainlands within the low latitudes.

The centers of commercial coconut production are the Dutch Indies, the Philippines, Ceylon, the islands of the western Pacific, and British Malaya. In the Philippines the industry in normal times is concentrated in the eastern and southeastern sections of the islands--particularly Luzon--where the rainfall is high and there is no prolonged dry season.[344] In the East Indies the commercial coconut industry is of greatest importance in Celebes, Western Borneo, Sumatra, Java, and the Moluc-

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342 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 430.

343 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 412.

344 Ibid., p. 413.

cas.[345] Other minor areas of production include the coastal margins of Queensland in northern Australia, the western coastal margins of British India, Mozambique, Madagascar, Congo Basin, Jamaica, Haiti, Honduras, Porto Rico, the northern coast and western tip of the southwestern peninsula of Trinidad,[346] Maracaibo Lowland of Venezuela,[347] Pacific Margin and Atrato Valley of Colombia,[348] eastern and western coastal lowlands of Mexico, Pacific Margin of Ecuador, Florida, and California. Brazil and the West Indies have been slow in developing coconut as a crop, but the production center may be moved from the Pacific to the Atlantic in order to lessen the distance required for transportation.

In the major producing areas the industry is primarily a native industry--most of the world's coconuts being raised on small native plantations; western capital is only directly interested to a minor degree. This is so because copra--dried coconut meat--is a mass product and not an article where quality counts heavily. The growing of coconut palms does not require a knowledge of specialized agriculture. It thus provides an excellent economic activity for natives who can sell their

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345 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 413.

346 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 689.

347 Ibid., p. 519.

348 Ibid., p. 548.

copra when prices are favorable or can keep their product from the market when prices are low. Modern plantations have not displaced primitive methods of growing coconuts since the production and cost of the two methods are about the same. However, in crowded countries--Ceylon and India--scientifically managed plantations are becoming predominant as it is more necessary to get the maximum yield per acre there.

The coconut palm is a true child of the tropics. It thrives best with continuously warm, wet weather provided that adequate sunlight is available.[349] An average of 75 inches of rainfall annually is required, with 35 to 40 inches as the minimum, provided then that the rainfall is distributed evenly. High humidity and high annual precipitation are essential. Coconuts can survive several months of drought if there is a good supply of water in the subsoil, but such periods have an unfavorable influence both on the palm itself and on its production of nuts.[350] As a result, the areas with conditions favorable for commercial production do not reach much farther than twenty degrees on either side of the equator.[351]

Although the coconut palm tolerates almost any soil except compact clay,[352] it thrives best where the soils are loose,

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349 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 411.

350 Ibid., p. 411.

351 Ibid., p. 411.

352 Ibid., p. 412.

sandy, and well-drained. Standing water is detrimental to the tree. Though coconut palms grow close to the seacoast, the soils must be free of salt.

The coconut palm requires an elevation less than 2500 feet. Shores seem to be the favorite habitat because there the palm commonly finds all requirements for its growth. The moisture supply is more likely to be constant close to the shore than elsewhere.

Strong winds can be withstood by this palm--even hurricanes, if they are not too violent.

Because the transportation is a heavy task, most groves are located near the coast so they may be water-served.

Wild trees are still an important source of coconuts, but for commercial purposes plantations are usually established. Mature nuts are planted in a nursery, and are barely covered. They germinate in a few months and the seedlings are transplanted when about a year old. Coconut growth is improved by proper spacing, clean cultivation, and intercropping. Cover crops, fertilization, and irrigstion also help to maintain the yield.

The first fruits appear in four to five years, though commercial bearing rarely begins before the seventh year. A coconut flowers and fruits continually through the year, so ripe nuts can be obtained during every month in the year. Ripe fruit can usually be picked every two months. The time and method of harvesting the nuts varies with the locality. In

Nicaragua the nuts are usually gathered from the ground after they have fallen from the tree. However, most nuts are climbed for by expert climbers who pick them. In Malaya the Chinese coolies rig up a bamboo pole with a short, stout, curved knife at the tip for releasing the close-packed bunches of coconut; this method is necessary here because the coconuts would sprout on the trees if not hand-gathered.[353]

A coconut palm reaches full bearing between twenty and forty years; some have been known to bear up to one hundred years of age. A well-cared-for tree gives seventy-five to two hundred or more nuts a year.[354]

After the nuts have been gathered, they are put into large heaps of 10,000 to 20,000 in the shade and there remain, drying out from a few weeks to several weeks, till the workers husk them. This is done by driving the cocomuts against a sharp spike fastened in a piece of wood, and wrenching them apart. An expert man is able to husk from 1200 to 2500 nuts a day. Machine huskers as yet are unsatisfactory because of the need of power which is either lacking or very expensive, and the great skill required in operating it since no two cocomuts are the same size and shape. A fortune awaits the inventor of a simple cheap, efficient, mechanical husker.

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353 Op. cit., p. 412.

354 Otis W. Barrett, Tropical Crops, The Macmillan Company, 1938, p. 259.

Following the husking, the nuts are split into halves with a blow of a heavy dull knife and the halves are then dried. This dried meat or copra is the most important commercial product, and probably 80 per cent of the coconut crop is made into copra.

Copra is prepared in several ways. About half the supply is dried by simple native methods, using the sun or drying on rocks over fires made from coconut shells. After a few days the coconut meat curls away from the shell, and can easily be removed. Copra prepared thus is dark colored and has an oil content of around 50 per cent. Plantation copra is dried within twenty-four hours by utilizing the sun during the day and heat from fires in the drying houses during the night. This copra is white and has a higher oil content, from 60 to 65 per cent. Best grades of copra come from southern India, followed by that from Ceylon, Java, Molucca, Manila, and Borneo.

It takes 3500 to 7000 nuts to produce one ton of copra which in turn yields 1200 pounds of coconut oil.[355]

The greater part of the coconut crop is shipped as copra to mills in San Francisco, Hull (England), and in normal times to Hamburg for extraction of the oil. Sometimes the extraction of the oil takes place in or near areas of production, but more often the copra is shipped long distances to the centers of

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355 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 368.

consumption in temperate zones.

Some of the copra is shredded and dried to form dessicated coconut. This is used by confectionery and candy makers, and in cooking. It is prepared from the best grades of nuts. They are cured for several weeks, and then carefully cracked and the meat is removed while fresh. This is washed, cut into "threads", and dried in a vacuum for an hour at 160° F. A few specially equipped desiccating plants in Ceylon[356] produce most of the desiccated coconut, shipping over 50,000 tons annually to the United States and Europe.[357]

Coconut oil is obtained from the copra. The oil is pale yellow and colorless, and is solid below 74° F. The cold-pressed oil is edible and now much used for food products, chiefly margarines; many artificial butters prepared from it are now on the market. Coconut oil has long been used for the best soaps, cosmetics, salves, shaving creams, shampoos, and other toilet preparations; it is also useful as an illuminant. About 500,000 tons of coconuts are used annually for oil.[358] Most of the oil is expressed in Europe, United States, and Japan, though Ceylon and India export large amounts.[359] Imports

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356 Op. cit., p. 370.
357 Ibid., p. 370.
358 Ibid., p. 220.
359 Ibid., p. 221.

of copra in 1935 reached 454,134,203 pounds while that of the inedible expressed coconut oil amounted to 353,406,265 pounds.

The coconut palm has many varied uses other than the two mentioned above. The fibrous husk yields coir (see p. 93). The hard shell is used for fuel, vessels, and other containers, and a fine grade of charcoal. The water makes an agreeable and refreshing drink. The unopened inflorescences yield a sweet liquid which is converted into palm sugar or fermented to make a palm wine (see p. 244). The leaves are used for thatching, baskets, hats, mats, and curtains. The heart at the apex of the stem is eaten in salads or is cooked. The bark contains a resin and the roots a drug.

Cocoa-Butter. A white or yellowish fat with a chocolate odor and flavor is expressed from the beans of the cacao or cocoa (Theobroma cacao) during the process of making cocoa. Although used somewhat in making chocolate, its chief use is for cosmetics and in perfumes and medicines.

A complete discussion of the cacao tree may be found on pages 64 to 74.

Cohune-Nut Oil. As yet the cohune-nut is little known, but predictions are that it may become a great future crop. The cohune-nuts are products of a wing-leaved palm (Orbignya cohune) a native of the tropical rainforests of Central and South America. The palm bears two to four huge bunches of nuts each year,

averaging 1000 to 2000 nuts per tree.[360] The nuts yield two oils: a kernel oil similar to coconut oil and an outside oil which is contained in the pulp surrounding the seed. The kernels contain 40 to 65 per cent oil in the form of a firm yellow fat; the outer fibrous husk of the nut contains 9 per cent to 36 per cent of a green fat.[361] Thus, each tree produces 100 pounds to 200 pounds of oil.[362]

Mexico, British Honduras, Honduras, northern Guatemala, Nicaragua, the Caribbean side of Panama, and Colombia and Brazil in South America furnish the cohune-nuts for the world markets. British Honduras alone is reported to have nearly two million acres (40 per cent of its total area) in wild cohune. Figuring forty palms to the acre, each palm producing two hundred pounds of nuts, this would give four tons of nuts to the acre, or eight million tons for that small country. The Scientific American reported in 1922 that thousands of tons of cohune-nuts go to waste annually in northern Guatemala. In 1929 an American company spent $700,000 in preparatory operations to grow cohune-nuts, but the business depression shut off the supply of necessary capital before the enterprise got into production.[363]

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360 Otis W. Barrett, Tropical Crops, The Macmillan Company, 1938, p. 290.

361 Ibid., p. 290.

362 Ibid., p. 290.

363 J. Russell Smith and M. Ogden Phillips, North America, Harcourt, Brace and Company, 1940, p. 906 (note).

It has been stated that Nicaragua could easily produce twenty-four million tons annually.

In the past the difficulty of finding a suitable machine to crack and crush the extremely hard walls of the nuts have prevented a more widespread use of the fat; but recently, effective machines have been devised and the fat is becoming of increasing importance in margarine manufacture and soap making.[364]

Kapok Oil. See under Kapok, page 100.

Mowra Fat. Mowra fat, also known by such names as bassia fat and mahua butter, is an Indian product whose source is the seeds of the fruit of several species of the genus Madhuca. These trees grow wild in the tropical rainforests of the East Indies, and they are also extensively cultivated in the same general vicinity.[365] The kernels of the seeds contain 55 to 65 per cent of a soft yellow oil widely used locally for cooking and tallow. Europe furnishes the best markets for these kernels, over sixty-six million pounds being imported from the East Indies for use as margarine, chocolate fat, and in soap manufacture.[366]

Nutmeg Butter. The seeds (nutmegs) of Myristica fragrans,

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364 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 223.

365 Ibid., p. 222.

366 Ibid., p. 222.

a tree growing in the East Indies, chiefly in the Moluccas and the Banda Archipelago, yield by expression a fat commonly known as nutmeg butter.[367] Only those nutmegs which are unfit for use as a spice are roasted and powdered; the seed meal is then pressed between warm plates to obtain the oily fat which, when cool, is of the consistency of butter or tallow. It is used for soap making, ointments, and candles.

This nutmeg butter is prepared both in Holland and the East Indies, including the island of Penang, the former being of higher quality.

Myristica otaba, a native of New Granada, yields a fat known as American nutmeg butter, or otaba fat.

A complete discussion of the nutmeg tree whose seeds furnish the nutmeg butter will be found on pages 237 to 241.

Palm Oil and Palm Kernel Oil. The African oil palm (Alaeis guineensis)[368] is the basis of the world's leading forest-gathering activity, and is also a competitor of the coconut in world markets for vegetable fats. Palm oil is a white vegetable fat, solid at ordinary temperatures, which is obtained from the fruit nuts of the oil palm. Each fruit consists of a yellow pericarp and a hard kernel; the former is rich in palm oil prop-

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367 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 96.

368 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 414.

er; the latter, in palm kernel oil.

Alaeis guineensis is a native of the tropical rainforests of West Africa (Guinea Coast) and the Congo Basin, but it has spread all through the t ropics and now covers enormous areas. It is even frequently cultivated. In West Africa the wild and semi-wild trees are found scattered extensively throughout the forests of the low damp coastal areas and the interior basins from Sierra Leone around the long sweep of the Guinea Coast to Angola, then back up the vast Congo Valley for hundreds of miles, up nearly to Lake Chad and out into the French Sudan. This area includes Nigeria, Sierra Leone, Belgian Congo, Dahomey, Ivory Coast, and French Cameroon.[369] This region alone supplies one-half the world's exports of palm oil and three-fourths of the world's exports of palm-oil kernels.[370]

In recent years extensive plantations have been established under western management in the Dutch East Indies (Sumatra and Java) and British Malaya; this area supplies one-half the world's exports of oil-palm nuts.[371] This new plantation industry here has proved to be a dangerous competitor of the African industry because it is producing a better grade of palm oil.

In the New World some oil-palm trees have been cultivated

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369 Clarence F. Jones, Economic Geography, The Macmillan Company 1941, p. 63.

370 Ibid., p. 63.

371 Ibid., p. 63.

in Brazil and the West Indies.

The environmental conditions prevalent in the Tropical Rainy climate favor the growth of oil-palms and the palm oil industry. The tree needs high humidity and rainfall of over 80 inches; it cannot stand a prolonged dry season.[372] Accompanying this high humidity and high rainfall throughout the year there must be constantly high temperatures. The oil-palm thrives best at the edge of the tropical rainforests or in less dense sections of the tropical rainforest where sunshine and light are plentiful, and where the soils are well-drained. In order to produce palm oil at marketable prices the industry requires plenty of cheap, skilled labor as well.

Palm-oil production in Africa is from semi-cultivated oil palms obtained by the "filling in" system. Under this system fairly good stands of wild oil-palms in various stages of growth are left after undesirable trees of other species have been cleaned out. This gives the foundation of oil-palm production by natives. Then one, two, or three year old volunteer seedlings from vigorous, heavy-yielding trees are carefully dug up during the rainy season and transplanted into the open spaces till the entire area is filled-in solid with oil-palm trees at distances of twenty to twenty-five feet. Thus consid-

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372 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 414.

erable time and space is saved by this "filling in" system; and it means a minimum of expense and delay in bringing a full outturn.

In the East Indies plantations are established on land owned by large companies on soils too poor for rubber. Seeds are planted in nursery beds and then transplanted into open fields, allowing sixty to eighty palms spaced to the acre. Under ordinary circumstances $40 brings an acre into bearing and covers clearing, planting, and cleaning of the plantation.

The oil-palm begins to bear at the age of five or six years, reaches full bearing at fifteen, and continues until sixty or seventy years of age. The tree has two fruiting seasons, and yields large crops. In a year a tree in full bearing has from twelve to twenty clusters of fruit, each cluster attaining from two hundred to more than a thousand small fruits. An acre of oil-palms yields 2500 pounds of palm oil from what is considered poor soil; higher yields are to be expected on better soils. Cultivated trees yield twice as much as wild ones. One ton of nut shells are obtained from an acre of oil-palms.

Natives are used in gathering the fruit. They climb the trees, select the ripened fruits, and carry rough bunches of fresh palm fruits for depulping and cracking. The fresh palm fruits are separated from the bunches for depulping. Depulping consists of boiling the palm fruits to soften the fruit. Then

they are pounded and squeezed in string net bags of coarse fiber for the reddish colored oil which is the palm-oil proper. The nuts of the palm fruit are removed from the pulp mass, and these are cracked for the inner oil-bearing kernels from which the oil is obtained by native presses or modern machine presses. Palm-oil extracting plants have been erected in Belgian Congo since World War I by large vegetable oil syndicates, and has resulted in a higher percentage of oil from the fruit. Sumatran mills obtain nearly 100 per cent of the available pulp oil since modern pulp extraction plants have been established there.

The oil-palm industry has three problems. The uneven ripening of the fruit in the clusters necessitates an extended harvesting season as well as the selection of only ripened fruit in each bunch. If gathering is delayed until all the fruits of the bunch are ripened, some of the fruits may drop off or at least start the dreaded oxidation process which forms free fatty acids in the pulp oil. Another problem of the industry is labor and transportation difficulties. Many regions of oil-palm production lack modern transportation facilities, and some regions have conditions which prevent railroads from being built inland to the oil-palm estates and plantations. If the cost of oil-palm production is to be kept down, there must be available an efficient, abundant, cheap labor. It is necessary that the cost be kept down as low as possible because of increasing competition from other vegetable oils.

Centers of consumption of palm-oil and palm-kernel oil are western Europe and the United States. In addition to oil from Africa (mainly Nigeria and Belgian Congo) the United States is importing increasing quantities of estate-produced oil from Sumatra. Most of the palm kernels are shipped to Europe. The manufacturing centers for the extraction of the oil are mainly in western Europe and the United States because here the efficient machinery for that purpose is to be had. The native farmers lack capital for modern machinery for extracting the oil; crude native methods do not obtain the greatest possible oil from the fruits. In 1935 the United States imported approximately 50,000,000 pounds of palm nuts and kernels, and approximately 338,000,000 pounds of palm-oil and palm kernel oil from various parts of Africa and the East Indian region.[373]

Palm-oil proper is yellow-orange or brownish red in color and is obtained from the pulp of the palm fruit; it is eaten by the natives, but its chief use is in the soap and candle industries, and in the manufacture of lubricants. The kernels of the fruit yield a different oil which is white in color and more valuable. Palm-kernel oil is used in the margarine industry because it has a pleasant odor. It is also used in soaps, candles, and glycerine.

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373 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, 1937, p. 227.

Pili-Nut Oil. See Pili Nuts, pages 199-200.

Sapucaia Oil. See Paradise Nuts, pages 198-199.

Volatile (Essential) Oils

Champaca Oil. Champaca oil is one of the most famous perfumes of India and other Oriental countries. The oil is distilled from the very fragrant yellow flowers of Michelia champaca, a large handsome tree of the eastern tropical rainforests.[374] It rivals ylang-ylang (see page 225) in its delicate fragrance.

Oil of Bay. The bay is known world over by its refreshing odor. The dark-leaved Pimenta acris, the bay tree, from whose leaves is distilled the oil of bay, ranges from the tropical rainforests of Mexico to Surinam (Dutch Guiana). The only large solid stand occurs on the island of St. Jan, two miles east of St. Thomas, in the American Virgin Islands; here there are several square miles of forest composed almost entirely of this bay tree. The tree is scattered in the forests through Cuba, Santo Domingo, Porto Rico--where it is semi-cultivated,--both the American and British Virgin Islands, on to Trinidad. The bay tree does not behave well under cultivation.

From these wild or semi-cultivated trees the thick fragrant leaves and small branches are slashed off by one man up

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374 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 206.

in the tree and stuffed into sacks by another on the ground, and then taken to the stills. Several hundred pounds of the leaves go into the kettle at one cooking. By process of distillation a volatile green (or in inferior grades, yellow) oil is obtained. One pound of this oil ranges in value from $1 to $2. An acre of bay trees should yield one to one and one-half tons of leaf in two or three slashings, providing an oil outturn from twenty-five to seventy-five pounds.

Oils of Cinnamon and Cassia. The waste, inferior pieces, broken quills, and chips of the bark of Cinnamomum zeylanicum when distilled yields the essential oil of cinnamon, which is used in medicines and as a flavoring agent. This oil is made chiefly in Ceylon and exported from there to the United States and Europe.[375]

From the leaves and twigs of Cinnamomum cassia, a similar oil, the oil of cassia, but having a stronger, less aromatic flavor is distilled.[376]

Both oils of cinnamon and cassia find use in the perfume industry. The United States imported 191,483 pounds of oil of cinnamon and 259,659 pounds of oil of cassia in the year 1935.

For a detailed discussion of Cinnamom zeylanicum, refer to to page 230 ; for Cinnamomum cassia, page 228.

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375 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 109.

376 Ibid., p. 109.

Oil of Cloves. See page 233.

Oil of Copaiva. A colorless or pale yellow medicinal oil is distilled from the oleoresin obtained by the incision of the stems of Copaifera langsdorfii, C. officinalis, and C. oblongifolia. These leguminous trees are natives of the Amazon Valley, but are grown also in other parts of tropical South America and the West Indies.[377]

Oil of Pimento. The unripe fruits of Pimenta officinalis, the allspice tree of Jamaica and other parts of the West Indies, Mexico, Central America, Venezuela, and Trinidad yields an essential oil. The tree bears small round berries which are gathered while still green, and carefully dried to form the familiar spice known as allspice or pimento. The oil is distilled from these unripe fruits. Similar oil is distilled from the leaves and is distinguished by the name of pimento-leaf oil.[378]

A complete discussion of Pimenta officinalis will be found on pages 226 to 228.

Nutmeg Oil. Nutmeg oil is discussed on page 241 under the topic Nutmeg and Mace.

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377 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 110.

378 Ibid., p. 106.

Sandalwood Oil. Sandalwood oil is used throughout the Orient as a perfume and also in medicine. It is obtained by distillation from the wood of Santalum album and allied species.[379] The sandalwood tree grows wild in India and other parts of southeastern Asia, and is cultivated throughout the Orient and many nearby tropical countries.[380]

In the year 1935 the United States imported 2,751 pounds of sandalwood oil.[381]

Ylang-Ylang. This is one of the most valuable and important oils in the perfume industry, and is present in almost every perfume. Ylang-ylang is derived by simple distillation from the exceedingly fragrant petals of the fully opened, yellowish green, bell-shaped flowers of Canangium odoratum, an eastern Asiatic species.[382] The tree grows wild, and in some cases is cultivated, in southeastern Asia and the East Indies, particularly in the Philippines, Java, and the island of Réunion.[383] The oil, often known as cananga oil, is produced chiefly in the Philippine Islands.

Even though rather expensive, this very fragrant essential

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379 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 206.

380 Ibid., p. 206.

381 Ibid., p. 209.

382 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 104.

383 Ibid., p. 104.

oil is in great demand, the best qualities being extensively used in the preparation of the best perfumes. In 1935 the United States imported 63,488 pounds of ylang-ylang oil.[384]

WAXES

Raffia Wax. In the preparation of raffia fiber (see page 106) from the raffia palm, Raphia ruffia, particularly in Madagascar, the whitish powdery wax on the undersides of the leaves is removed and forms raffia wax.[385] The powder is sifted and placed in boiling water, the melted wax being skimmed off and cooled in a shallow vessel. The wax is yellow to brown in color. There are large quantities of raffia residue available in Madagascar, but only small quantities of the wax are prepared at present.

SPICES AND FLAVORING MATERIALS

Allspice. Allspice--so named because of the fact that its flavor resembles a combination of cinnamon, clove, and nutmeg--is the dried unripened fruit or berry of Pimenta officinalis, a small evergreen tree native to the humid tropical lowlands of the West Indies and other islands of the Caribbean, Mexico, Central America, and Venezuela in South America. This spice is also known as Jamaica pepper or pimento, the word pimento being

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384 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 209.

385 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 99.

derived from pimienta, the Spanish word for peppercorns which the spice resembles in shape.

Although grown to some extent in all humid lowlands of the American tropics, allspice is most abundant in Jamaica, the result being that this island has a virtual monopoly, and produces the greater part of the commercial spice, exporting from 4000 to 5000 tons annually.[386] Other areas where the tree occurs include Mexico, Central America, Venezuela, Cuba, Haiti, Trinidad, and more or less in most of the islands of the Caribbean Sea, but it does not appear to have been cultivated successfully elsewhere.[387]

The American tropical lowlands of the Caribbean area meet the environmental requirements necessary for the production of allspice: the combination of high temperatures, high rainfall, and high humidity throughout the year; well-drained soils; and cheap but not necessarily skilled labor, since only simple processes are involved in preparing allspice for market.

In some areas allspice-bearing trees are grown on plantations, but in Jamaica the abundance of the wild product makes it unnecessary to cultivate the tree. The allspice tree grows slowly and begins to bear when about seven years of age, and continues for twelve years, with an average yield of 75 to 100

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386 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 474.

387 James B. McNair, Spices and Condiments, Field Museum of Natural History, Chicago, 1930, p. 40.

pounds per tree.[388] When ripe, the berry-like fruits are purple; but since the ripe fruits lose most of their aromatic qualities, the commercial product is collected when the berries are mature but green. The branches bearing bunches of the berries are broken off, and the fruits are removed by hand or flail. The ripe and undersized berries are discarded, and the desirable ones are dried in the sun or over fires for several days. They become wrinkled and turn a dull reddish brown while the aroma becomes more pronounced.

Imports of allspice into the United States from the American tropics in 1935 amounted to 4,127,822 pounds.[389] Its use is chiefly for flavoring confectionery, pickles, and other foods.

Cassia. Cassia, or Chinese cinnamon, is one of the oldest of spices. It was known in China as far back as 2500 B. C., in Egypt in the 17th Century B. C., and was familiar to all peoples of the Mediterranean area at an early date.

Both the cassia bark and cassia buds--dried unripe fruits--are obtained from Cinnamomum cassia, an evergreen tree native to Burma and southern China. This species is found growing wild in the Malay Archipelago, while those in southern China are cultivated, being grown there from seed, usually on the

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388 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 474.

389 Ibid., p. 496.

terraced hillsides.[390] The Chinese territory in which Cinnamomum cassia is grown is comparatively limited--the provinces of Kwang-si and Kwang-tung--a district bounded on the north by the Si-Kiang and extending southward as far as 23° 3' North Latitude, and lying between 110° and 112° East Longitude.[391]

The requirements for the growth and production of cassia are similar to those of the true cinnamon. (See page 230.)

When the young trees are from six to ten years of age, they are cut down and cut up into short lengths.[392] The bark is loosened, stripped off, and dried. Cassia bark reaches the markets in the form of dark reddish-brown "quills", usually with some patches of grayish cork on the outside. Though the quality may vary, the bark is always very aromatic though not so delicate and fine as cinnamon. Cassia bark sells at a lower price than cinnamon, and its chief use is as a substitute for it. An essential oil is distilled from cassia bark. Cassia bark and cassia oil are used in medicine, for flavoring purposes, in soap, candy, and perfumery.[393] The United States imports cassia chiefly from China and Sumatra.[394] Statistics

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390 James B. McNair, Spices and Condiments, Field Museum of Natural History, Chicago, 1930, p. 12.

391 Ibid., p. 14.

392 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 468.

393 Ibid., p. 468.

394 Woon Young Chun, Chinese Economic Trees, Commercial Press, Ltd., Shanghai, 1921, p. 154.

show that our imports for 1935 reached 10,093,196 pounds.[395]

The dried unripe fruit of the Chinese cassia tree (Cinnamomum cassia) are called cassia buds.[396] After flowering, the sepal of the flower swells and forms a cup in which the small black olive-like fruit sits like an acorn in its cup. They are gathered when only one-fourth grown and resemble little cloves in appearance, but are smaller. While the cloves are flower buds, the cassia buds are not. The odor and flavor of cassia buds is similar to that of cinnamon so that spice is used in place of cinnamon in confectionery. Spice from cassia buds is popular among the Oriental nations; and the Germans and Russians prefer cassia to cinnamon for flavoring chocolate because it is stronger in taste.

Cinnamon. Cinnamon is among the oldest spices known and is one of the most popular and useful spices used in flavoring foods. Cinnamomum zeylanicum, whose bark is the source of the cinnamon, is a small evergreen tree. It is from the inner bark of the young shoots, twigs, and small branches of this tree that the cinnamon of commerce is obtained.

The original habitat of the true cinnamon tree is the tropical rainforests of southwestern Ceylon.[397] For many years this tree was grown only in Ceylon, but now it can be found

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395 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 496.

396 Ibid., p. 467.

397 Ibid., p. 468.

cultivated in the moist tropical portions of the western as well as the eastern hemispheres. The cinnamon tree is cultivated principally in the damp lower hillsides and coastal plains of southwestern Ceylon--the center of the present cinnamon production.[398] On the island of Penang, not far from Ceylon, grow the world's choicest cinnamon.[399] Minor centers of cinnamon production include the Malabar coast of southern India, Burma, Malaya, Java, Réunion, Uganda, Cape Verde Islands, Brazil, French Guiana, and Jamaica. Attempts to cultivate the tree in many other parts of the world have been made, with but little success. Ceylon still holds the cinnamon market.

The areas of commercial production are restricted because of the environmental factors necessary for the cultivation of the cinnamon tree. The cinnamon tree is extremely sensitive to soil and climate. The climatic requirements: high temperatures throughout the year; high rainfall with accompanying high humidity; plenty of sunshine, for trees exposed to the sun during growth are more acrid and spicy than those grown in the shade.[400] The soil must be light and sandy to provide good drainage. The best quality of cinnamon is produced where the trees are grown at low altitudes close to the ocean. Here the

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398 James B. McNair, Spices and Condiments, Field Museum of Natural History, Chicago, 1930, p. 16-17.

399 Ibid., p. 17.

400 Ibid., p. 17.

combination of intense heat and salt sea breezes results in a highly aromatic bark. Rarely are plantations higher than 2500 feet above sea level, for at altitudes higher than that the bark has very little true cinnamon taste. Cheap skilled labor is also necessary in the harvesting and preparation of cinnamon for market. The labor supply available in the East Indian region is superior to that of other humid tropical regions of the world in abundance, intelligence, and skill.

Until about 1765 the bark was obtained from cinnamon trees growing wild in the forests of the tropical jungles; after that, cultivation of cinnamon trees from seed was started and was continued by the Dutch in the East Indian region under the plantation system. On the plantations the trees are kept pruned to bush form, since the aim of the cinnamon industry is to obtain as much bark as possible. In cultivation the young trees are cut back and sucker shoots develop from the roots. These are low and slender, and furnish the commercial product. The best bark comes from two year old shoots, the bark of younger ones having very little flavor. However, if the crop of bark is obtained from larger branches of wild trees, it is removed once every three years, thus allowing time for the renewal of the bark by the tree.

Cinnamon bark is collected from the larger branches by stripping, or the branches and shoots are cut and collected. Harvesting takes place after the first rains of the season,

when the sap begins to circulate between the wood and the bark. Usually there are two harvest a year, occurring during the rainier seasons of the year. The bark is carefully peeled off, the outer and inner portions are scraped off, and then the so-called quills are dried and tied up, ready for shipment, largely to the United States and European countries, particularly England. The United States imported 850,356 pounds of cinnamon bark in 1935.[401]

The cinnamon bark is used mainly as a spice; but it is also used in the manufacture of candy, gum, incense, dentrifice, and perfumes. The waste, inferior bark, broken quills and chips are used as a source of oil,[402] the oil of cinnamon being made chiefly in Ceylon for exporting. The oil is used as a carminative, antiseptic, astringent, and as a source of cinnamon extract.

Cloves. The dried unopened flower buds of the clove tree, a tropical evergreen tree (Eugenia caryophyllata), provide one of the most important and useful of the spices.

The clove tree was found originally growing in a wild state in the Molucca or Spice Islands.[403] During the 17th and 18th centuries the Dutch had a virtual monopoly on the trade in

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401 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 496.

402 Ibid., p. 469.

403 Ibid., p. 471.

cloves. This monopoly was broken by the French who succeeded in transplanting some clove trees to their island possessions in the Indian Ocean (Réunion). At present most of the cloves entering world trade are produced on the islands of Zanzibar and Pemba on the east coast of Africa, which together grow 90 per cent[404] of the world's supply. Zanzibar not only is one of the two chief clove producers, but also produces the world's largest cloves. Penang, off the west coast of the Malay Peninsula, furnishes the world's choicest cloves.[405] Other minor clove-producing areas include Sumatra, Java, Ceylon, Réunion, Amboina, Madagascar, the Guianas, the West Indies, as well as the Spice Islands. Thus, at one time or another, the clove tree has been introduced into nearly all parts of the tropics, but comparatively few attempts have been made in most tropical countries to cultivate it on a large scale. Because the tree is of relatively slow growth and its product is of limited demand, a very extended area of cultivation is not required to stock the world's market.

The regions of commercial clove production are within the Tropical Rainy climate. Certain environmental factors are necessary to clove production: high temperature throughout the year; plenty of rain with accompanying high humidity; good

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404 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 105.

405 Edgar H. S. Bailey and Herbert S. Bailey, Food Products from Afar, The Century Company, 1922, p. 145.

soils; nearness to the ocean for the production of best quality cloves--the intense heat together with salt sea breezes results in a highly aromatic spice;[406] and cheap, skilled labor. There is considerable skill involved in the preparation of cloves for market. In addition there is a necessity for cheap labor in order to keep the price of the product low.

Formerly clove production was a forest type of industry involving the gathering or collecting of cloves from the trees growing wild. At present it is a plantation industry only, scattered throughout the tropics, with greatest importance in the East Indian region. These plantations are under direct foreign control with natives working under white supervision. Clearing tropical rainforests and jungles to establish thriving plantations involves many difficulties. In addition, deadly fevers, poisonous snakes, swarms of maddening insects add to the difficulties of plantation development.

Cloves are hard to grow. They are raised from seed; cuttings are useless, and the seeds germinate and grow slowly. The young seedlings must be very carefully shaded and watered. When about six inches in height, the seedlings are gradually exposed to the full force of the sun and then planted out in regular rows at distances of about 25 feet. In about five years the trees begin to bear blossoms, but commercial bearing is not usually reached until the tree is from five to seven

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406 Op. cit., p. 144.

years old, and tree-bearing lasts until the tree is nearly one hundred years old, if well cared for and well situated.[407]

The harvesting of the young unopened clove buds commences in August and lasts until about November, each tree being picked on an average of three times a season. Although the trees usually bear but a single crop a year, in some cases two crops a year are produced, but this is not dependable from year to year. The young unopened buds are reddish or greenish at the time of harvest.

Two methods of harvesting may be employed: beating or shaking the branches so that the young unopened flower buds and stalks drop onto a cloth spread beneath the tree; or picking the flower buds by hand on a movable stage to enable the pickers to reach the upper branches. The latter method is used in Zanzibar. Then the buds are dried either in the sun or over a fire, both methods requiring about a week's time. Upon drying, the flower buds become brown and brittle.

The demand for cloves is still from countries of the North Temperate lands, especially the United States and those of Europe. Imports of cloves by the United States in 1935 reached 3,774,555 pounds; that of clove stems (used to adulterate cloves), was 328,397 pounds.[408] There has, however, been a

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407 Forrest Crissey, The Story of Foods, Rand McNally and Company, 1917, p. 447.

408 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 496.

steady decline in the demand for cloves because they are needed far less now than in the past. More varied food and better preserved than formerly, modern refrigeration, new substitutes for distant products--all these have been responsible for the decline in the demand for cloves. India which still requires cloves to make the food palatable and to give variety to their diet imports large quantities from clove-producing regions nearby.

Cloves are still used mainly as a spice. An essential oil is obtained from cloves:[409] the cloves are ground and boiled with water, and the steam that comes over is condensed and put back several times into the still, so that finally all of the essential oil shall be extracted; the boiling is then continued and the condensed steam collected, when the oil readily separates out from the water upon standing. This oil is used in medicine and dentistry, as a flavoring oil, in perfumes and scenting soaps. The United States imported 8,468 pounds of oil of cloves in 1935.[410]

Nutmeg and Mace. Once valued highly among the spices, nutmeg and mace have lost much of their former popularity. Both of these spices are obtained from the fruit of the same tree--

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409 Edgar H. S. Bailey and Herbert S. Bailey, Food Products from Afar, The Century Company, 1922, p. 145.

410 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 209.

Myristica fragrans[411] --more commonly called the nutmeg tree. The fruit is oval or pear-shaped, orange-yellow in color, and somewhat resembling apricots or pears. When the fruit becomes dead ripe, the husks split in half, exposing the seed enclosed in a deep round shining seed-coat, and over this there is a crimson lace-like network, the mace.[412]

Although native to the Moluccas or Spice Islands,[413] the nutmeg tree is now grown in the tropics of both the Eastern and Western Hemispheres. Upon the discovery of the Spice Islands in 1512 the Portuguese obtained a monopoly on nutmeg and mace, a monopoly which was later wrested from them by the Dutch. At a still later date nutmeg trees were smuggled into the French and British possessions, and the monopoly thus became broken, resulting in the distribution of these trees to other locales within the tropics. The principal region of commercial production today is the East Indies, including the islands of Banda, Penang, Java, Celebes, and Amboina. In addition, nutmeg trees are grown to a smaller extent in Zanzibar, Réunion, Madagascar, the islands of Grenada and Jamaica in the West Indies, along the northern coast of South America, and Brazil.[414]

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411 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 487.

412 James B. McNair, Spices and Condiments, Field Museum of Natural History, Chicago, 1930, p. 39.

413 Op. cit., p. 487.

414 Z. Carleton Staples and G. Morell York, Economic Geography, (third ed.), Southwestern Publishing Co., 1940, p. 258.

The nutmeg tree is limited to regions having the Tropical Rainy climate because of its requirements of a high annual rainfall with accompanying high humidity, and high temperatures throughout the year. Like the clove, nutmeg trees thrive best when near the sea, so that the tropical islands are most favorable for their growth.[415] A good soil which is well-drained is necessary, too. Considerable skill is needed in the preparation of the nutmeg and mace for market. The East Indies are favored with having an abundant supply of cheap, skilled, intelligent native workers. As in the case of other tropical spices cheap labor is a necessary requirement for economic production of nutmeg and mace in order to keep the price of the product low enough to withstand market competition.

Nutmeg trees are propagated in nurseries from seeds much as cloves are, demanding the same care and protection from the sun during the early stages of development. Land cleared for nutmeg plantations are set out with young trees in rows about twenty-five feet apart. One of the problems of nutmeg production is the uncertainty of the tree sex. Only the female trees supply nutmegs, and since these cannot be distinguished from the male trees until six or seven years old, it may mean the loss of time and involve tremendous expense if a plantation is found to contain many male trees. The problem has been solved

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415 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 489.

by the practice of grafting a branch of a female tree to all young trees when they are two years old--before the tree sex can be distinguished--in order to insure the fruiting of the trees.

These trees bear their first fruit in about eight years, and about the ninth year begin to yield enough fruit for commercial purposes.[416] Full bearing, however, is not reached until the tree is about fifteen years of age, and continues thereafter for ten to twenty years.[417] Nutmeg trees have been known to bear until seventy-five years old. The yield per tree is very high, a full-grown tree furnishing from 3,000 to 10,000 nutmegs annually.[418]

Although ripe fruits are produced all year round, two crops are harvested each year. The principal harvest occurs during October, November, and December, and a smaller one in April, May, and June.[419] The natives gather the fruit from the trees, picking only those whose husks have split open. Then the pericarp is removed and the red lace-like aril is carefully stripped from the stone of the fruit, flattened, and dried to give the mace of commerce. The stones are placed over a slow fire to dry; then the shells are cracked, the kernels or nut-

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416 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 489.

417 Ibid., p. 489.

419 Forrest Crissey, The Story of Foods, Rand McNally and Com-
418 pany, 1917, p. 451.
Op. cit., p. 496.

megs are sorted, and then often treated with lime to prevent insects attacking them.

The chief markets for nutmeg and mace are the countries of the temperate lands, especially the United States and the countries of Europe. The United States in 1935 imported 4,420,911 pounds of nutmeg and 702,627 pounds of mace.[420] Mace is always in good demand and usually costs more per pound than nutmeg, as there is less produced per tree.

Both nutmeg and mace are used chiefly as a spice. From nutmegs which are unfit for use in the spice trade nutmeg oil and nutmeg butter are obtained. Nutmeg oil is extracted from the roasted and powdered nutmeg seeds and is used in medicines, flavoring extracts, perfumes, tobacco industries, and in dentifrices.[421] Nutmeg butter is a fixed oil which is obtained by crushing and pressing the nutmeg seeds; this is made chiefly in the East Indies and Penang for use in soap making, ointments, and for candles.

Star Anise. Illicium verum, a small evergreen tree, which is probably a native of China bears the fruit known as star anise.[422] The fruits are star-shaped and reddish brown in color. Within each fruit are eight hard shiny seeds.[423] Both the

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420 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 496.
421 Ibid., p. 489.
422 Ibid., p. 479.
423 Ibid., p. 479.

seeds and the fruits are highly aromatic with a flavor of anise.

The plant is cultivated from seed only in southern China and Indo-China. Because it is strict in its climatic requirements, and because of its slow and hazardous development, it is not grown more frequently. The tree yields at from six to one hundred years of age, often producing two crops a year.[424] The fruits are collected before they are ripe and are dried, or are immediately distilled for the oil.[425]

The use of star anise as a culinary spice is limited to the Far East. It is often chewed to sweeten the breath and as an aid to digestion. The oil which is obtained is used in medicine, as a carminative, expectorant, and flavoring material.

Tonka Beans. There are two species of tropical South American trees--Dipteryx odorata and Dipteryx oppositifolia--which are the sources of tonka beans[426] whose importance as a flavoring material substitute for vanilla is rapidly increasing. These trees which grow as high as one hundred feet and may have diameters of three feet bear curious egg-shaped fruits having a hard shell and pulpy flesh surrounding a single, fragrant, odoriferous seed. The seed is referred to as Tonka, Tonqua, or Tonquin bean and resembles vanillin in odor.

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424 Op. cit., p. 479.
425 Ibid., p. 479.
426 Ibid., p. 479.

The tonka-bean tree, as it is commonly called, is believed to be a native of the tropical rainforests of the Guianas. At present it grows in a wild state in the tropical rainforests of Brazil, the Guianas, and Venezuela. The tree grows chiefly, however, in the Caura (or Coura) and Cuchivero Valleys of the Orinoco Basin, involving the western portion of the tropical rainforests of the Guiana Highlands.[427] In 1940 tonka-bean plantations, established in parts of the West Indies, gained prominence, and the onka-bean became the agricultural boom crop there.[428] The use of tonka-beans in flavoring cigarettes have resulted in their high price and was responsible for starting this boom. This boom in tonka-bean plantations will probably soon be overdone.

In the Caribbean countries of South America where the tree grows naturally in the tropical rainforest, the natives collect the fruits as part of a forest-gathering activity along the rivers, then break them open, and dry the seeds. These seeds resemble Jordan almonds and have a black wrinkled surface. It is only in parts of the West Indies that it has become a plantation crop.

Because the flavor of the tonka beans and their extract strongly resembles vanillin, they are used in the adulteration

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427 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 658.

428 J. Russell Smith and M. Ogden Phillips, North America, Harcourt, Brace and Company, 1940, p. 872.

of vanilla, and is employed as a substitute for vanilla in cocoa, confectionery, and ice cream; but because of the presence of cheap vanillas on the markets, it has been hitherto unprofitable to market these seeds in quantity. The beans contain a crystalline substance, coumarin, which is of considerable importance in the manufacture of perfumes and sachet powders.[429] Tonka bean or its extract is also used to flavor snuff, cigars, cigarettes, and smoking tobacco.[430]

Tonka beans are sent in large quantities to the United States, being the most important item of trade from Ciudad Bolivar, Venezuela. In 1935 imports of tonka beans reached 514,741 pounds.[431]

SUGARS AND STARCHES

Palm Sugar. The juices of several species of palm trees constitute a source of commercial sugar called jaggery or khauri. This source of sugar is available only in the tropics,[432] since the palm is limited to this climatic portion of the world. The chief species from which sugar is obtained are the wild date (Phoenix sylvestris), the palmyra palm (Borassus

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429 James B. McNair, Spices and Condiments, Field Museum of Natural History, Chicago, 1930, p. 59.

430 Ibid., p. 59.

431 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 496.

432 Ibid., p. 238.

flabellifer), the coconut palm (Cocos nucifera), the toddy palm (Caryota iurens), gomuti palm (Arenga pinnata), and the African oil palm (Alaeis guineensis).[433]

Wild Date Palm. The wild date palm is tapped for its sap quite like that of the maple tree. (See page 522.) The sap is obtained from the tender upper portions of the stem. The wild date palm of Jessore and other districts of Bengal, in India, is of importance in this regard. A fair estimate places the annual production of Indian palm sugar at about 100,000 tons.

Tapping begins when the tree becomes six or seven years old, and is continued each year thereafter. The tapping preparations begins as soon as the rainy season has passed, around November, and lasts for four and one-half months. In December and January the juices flow best. The colder and clearer the weather the more copious and rich the juice. The flow of juice decreases with the coming of warm days in March.[434]

The lateral leaves of one half the tree's circumference are cut off, and this leaves bare a surface measuring ten to twelve inches square. After a few days actual tapping operations begin by making a broad V-shaped cut into this exposed area. Then the portion inside the angle of the V is cut deeper, so that a triangular surface is cut into the tree. From

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433 James B. McNair, Sugar and Sugar-making, Field Museum of Natural History, Chicago, 1927, p. 29.

434 Ibid., p. 31.

this exudes the sap into a bamboo cutting inserted into the tree, and the sap is carried out as if by a spout into a pot hanging beneath.

Tapping is arranged throughout the season in six day periods. Juices flow at night. It is then collected in the morning because the flow of sap stops during the day. On the first two evenings V-shaped cuts are made, the second close to the first one but not nearly as deep as the preceding. The juice is the strongest and best from the first cut; that of the second is not quite so abundant or as good as that of the first. On the third evening no new cut is made, but the exuding surface is cleaned and the flow of sap is collected. These three nights are periods of activity. Then the tree is allowed to rest for the three succeeding nights after which the same process is repeated. Thus, each tree averages sixty-seven tapping nights, and at five pints of juice each night it equals 335 pints per tree.

Every tree in the grove does not run in the same cycle; some are at different stages of the six-day period. Thus, the owner is always busy tapping and collecting from some of the trees in his grove. Cuts during one season are made about the same place on the tree, but in alternate seasons alternate sides of the tree are used for tapping. A tree over forty-six years old is worth little as a sugar producer.

The boiling process is usually done in the vicinity of the

grove by the tapper himself. The juice is boiled down to gur, and is then sold to sugar refiners and by them is manufactured in various ways into different grades of sugar. Each tree produces enough juice to make forty pounds of gur or molasses.

Palmyra Palm, Coconut Palm, Gomuti Palm, and African Palm. The sap of these palms is obtained from their unopened inflorescences. These palms do not bloom until they are twelve to fifteen years old.[435] The sugar gathering season lasts for several months, beginning with the appearance of the spadices, in November or December. Usually the tips of these are cut off and the sap oozes out and is collected in various sorts of containers. A spadix gives "toddy" for about five months at the rate of three to four quarts a day. Seldom more than three spadices yield "toddy" on the coconut tree at the same time, but on the palmyra palm seven to eight will yield juice at once. An expert climber can draw "toddy" from about forty trees in a few hours. The "toddy" has a sugar content of about 14 per cent.

To obtain sugar from the sap, the "toddy" is boiled until it becomes a thick syrup; then it is poured into small baskets of palmyra leaves to cool and harden into the crude sugar known as jaggery. About three quarts of "toddy" makes one pound of crude sugar or jaggery.

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435 James B. McNair, Sugar and Sugar-making, Field Museum of Natural History, Chicago, 1927, p. 27.

Sago Starch. This starch, called sago, is obtained from the stems of the sago palm (Metroxylon sagu), a tall tree which grows in low and swampy regions, such as the valleys and deltas of many rivers in the tropics.[436] It is native to the East Indian region and is cultivated in Malaya and the East Indies. The sago production industry should easily be one of much profit and interest. The vast reaches of the sagu swamp in the almost unexplored Agusan Valley of northeastern Mindanao could starch-feed the whole island.[437]

Just prior to the time the flowers appear, which is when the trees are about fifteen years old, the stem of this palm has stored up in it a large amount of starch. The starch is the reserve food supply of the palm which it stores up in its trunk during many years of growth in preparation for the production of its flowers, fruit, and seed, which it does only once, and then dies. Therefore, in order to get the maximum amount from each palm, it is necessary to cut it down just before it puts forth its flower or fruit stalks. An acre produces about 2500 pounds of sago starch.

The trees are cut down, the trunk cut up into sections, the hard outer rind split open, and the pith removed. This is pounded and mashed, mixed with water, and strained through a

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436 Albert B. Lewis, Use of Sago in New Guinea, Field Museum of Natural History, Chicago, 1923, p. 1.

437 Otis W. Barrett, Tropical Crops, The Macmillan Company, 1938, p. 289.

coarse sieve. The starch is allowed to settle to the bottom. The excess water is poured off, and the starch is then dried in the sun or ovens, and appears as hard shiny grains, known as pearl sago.

Both sago starch and pearl sago are used almost entirely for food purposes.

The United States imported 1,175,010 pounds of crude sago and 23,631,003 pounds of sago flour in 1935.[438]

TANNING MATERIALS

Mangrove. Of all tannin extracts obtained from trees mangrove is one of the cheapest; therefore, it has become very important in recent years, both in this country and abroad, for it yields twice as much tannin as quebracho. Mangrove holds forth great promise for the future since the supply of mangrove is extensive and virtually untouched. Although all species of the mangrove contain tannin--the white, black, and red--the bark and leaves of the red mangrove (Rhizophora mangle) form the chief source, and so far has been the species chiefly exploited.[439] The bark contains 40 to 55 per cent tannin, and the leaves also are rich in tannin content.

The original habitat of the red mangrove is the tidal swamp area of the tropical and subtropical countries in both

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438 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 254.

439 Ibid., p. 136.

the eastern and western hemispheres.[440] Most of the present commercial supply comes mainly from Mozambique, nearby Madagascar, tropical South America, the East Indies, and tropical Central America.[441] The tidal swamp areas about the mouths of the Amazon River in Brazil, the low swampy coastal and deltaic plains of Colombia, the coastal marginal fringe and river swamps of the Guianas, Venezuela, Trinidad, Central America, the east and west coasts of Mexico,[442] and the West Indies[443]--all are regions of present exploitation in the western hemisphere. The tidal swamps of southern Florida, the Mississippi delta, and the Texas coast contain all three species of mangrove and form a region of possible future exploitation; but the excessive cost of cutting, transporting, and delivering the product to market has delayed the development of this region as a source of tannin.[444] Thus, the present areas of production are within the Tropical Rainy climate; the Humid Subtropical regions are not as yet of commercial importance, but have future promise.

The red mangrove requires high yearly rainfall and high temperatures at all times throughout the year. It thrives in

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440 Op. cit., p. 136.

441 Clarence F. Jones, Economic Geography, Henry Holt and Company, 1935, p. 250.

442 Liberty H. Bailey, Cyclopedia of American Agriculture Vol. III, The Macmillan Company, 1907, p. 627.

443 Ibid., p. 627.

444 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 83.

the low coastal swamps or river swamps of the tropics and subtropics, its roots covered by water at all times.

Both the bark and leaves of the red mangrove are collected from the wild trees of the tropical rainforest by native workers. The bark is merely stripped from the stems and branches, broken up into small pieces, and dried in the sun, preferably under some type of overhead cover. When dry, the bark is packed into bales weighing about one hundred pounds each and sent to factories for extraction of the tannin. The process of extraction is somewhat similar to that employed in quebracho, but is more difficult. The manufacture of mangrove tannin extract is carried on on a considerable scale in Borneo and some other East Indian Islands. In Brazil the leaves, which are also rich in tannin, are gathered and used in tanneries in southern Brazil, in Santos and Cartagena. The peculiar habits of mangrove growth render it difficult to cut; transportation of the bark from the swamps add further to the problems of the industry; skilled, cheap workers are necessary to collect the bark with greatest efficiency, least damage to the trees, and to keep the cost of tannin extract as low as possible in competition with others on the world markets.

The United States, United Kingdom, and France import large quantities of mangrove extract and bark. Our imports in 1935 of mangrove extract and bark totaled some 25,643,387 pounds.[445]

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445 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 152.

The tannin extract is used for tanning sole and other heavy leathers. It is rarely used alone because it gives a dark red color to the leather and causes it to be brittle; therefore, for best results, the extract is mixed with other agents.

MISCELLANEOUS

Vegetable Ivory. One of the most important products of the Amazon forests of South America is the tagua nut, more commonly called "vegetable ivory". The chief source of this vegetable ivory is the tagua palm (Phytelephas macrocarpa) which is native to the swamps and wet lowland forests of western Colombia and Ecuador.[446] This palm is a low-growing tree; each tree contains huge "negro head" clusters of six or seven adhering drupe-like fruits, each with anywhere from half a dozen up to forty nuts or seeds. The individual "ivory nut" is the size of a chestnut, being hard, white, fine-grained, and resembling genuine ivory, wherefore the name--"ivory nut".

The principal region of commercial production lies over the Andes from the Amazon forests, in the rich Pacific forests of tropical South America. Here the tropical forests of western Ecuador near the Pacific margin and those of the Magdalena River Valley of western Colombia[447] are the two most important

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446 Otis W. Barrett, Tropical Crops, The Macmillan Company, 1938, p. 289.

447 Clarence F. Jones, South America, Henry Holt and Company, 1930. p. 524.

tagua-producing areas; other minor areas exist throughout the Pacific tropical rainforests from Panama southward to southern Ecuador.[448] Within this entire area the tagua palm grows wild, and the nuts are gathered by natives as part of a forest-gathering industry. Vast areas of tropical rainforests favor growth of tagua trees on plantations but the low value of the product prohibits the establishment of costly plantations and restricts the output to activity of native tagua-gatherers. Therefore, a marked expansion on plantations is not to be expected.[449]

The growth of tagua palms is favored in tropical rainforests because there the rainfall is high all year and is accompanied throughout by high temperatures--two climatic conditions required by this palm for best development. Furthermore, the tagua industry depends upon a cheap, abundant labor supply and satisfactory means of transportation from the forests to the export cities. In recent years of high prices it has been difficult to secure sufficient numbers of natives to go into the forests to collect the nuts.[450] Within the tropical rainforest the lazy negroes reluctantly sacrifice leisure to even gather tagua nuts.

After the fruit of the tagua palm ripens, the drupes fall to the ground and usually burst open, the nuts either falling

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448 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 53.

449 Ibid., p. 524.

450 Ibid., p. 524.

out or sticking in the fibrous pulp.[451] The tree produces fruit the year round, but the principal crop comes during the months of January to May; thus, the tropical fruiting throughout the year gives a fairly even flow of nuts to the markets of the world. Rodents and other wild animals of the tropical rainforests, fond of the pulp, eat it and thus clean the nuts which are then gathered by the natives from the ground. These natives go into the deep forests for days at a time in search of the tagua palm trees which are widely scattered through the forests. The nuts are brought out on the backs of natives or mules, or in small boats, if rivers are nearby. These are then sold by the natives to merchants who dry them and ship them.

Europe and the United States buy up most of the exports of tagua nuts. Since World War I the United States has taken over one-half the normal output. In 1935 imports of tagua nuts amounted to 12,200,462 pounds.[452] This vegetable ivory can be carved and turned, and so finds an extensive use in Europe and the United States as a substitute for true ivory in the manufacture of buttons, chessmen, knobs, inlays, and similar articles.

The tagua nut industry is faced with several problems. At present there is competition from many cheap imitations.

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451 Op. cit., p. 524.

452 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 254

The low cost of imitation ivory and the resulting lack of world demand for tagua nuts keeps the production of tagua nuts down below what could be produced for market. Another problem is the difficulty of securing sufficient dependable workers. The price of rubber always affects tagua production. The natives prefer the hard life of rubber gathering to the easier work of collecting tagua nuts; therefore, when the price of rubber rises, the natives abandon tagua-nut gathering in favor of rubber-gathering. The result is that the demand for rubber directly affects the supply of ivory for buttons and ornaments.

CHAPTER VII

TREE CROPS OF THE MONSOON TROPICAL (TROPICAL SAVANNA) CLIMATE

The Monsoon Tropical or Tropical Savanna climate has a natural vegetation called savanna, which consists of a mixed plant association of grass and trees, marking the response to a definite season of rain and drought. The character of the savanna varies from the dense monsoon forest on the equatorward margins to the dry thorn-forest on the poleward margins. Because this region is predominantly a luxuriant grassland, on the whole only a few tree crops of commercial importance come from lands under this type of climate. Those which merit discussion include: Nux-vomica, a drug; cutch and red sandalwood, two dyes; Kadaya gum; shea-butter, a fatty oil; and divi-divi and myrobalans, two tanning materials.

Nux-vomica. This valuable drug whose use dates back to the sixteenth century is obtained from the large peculiarly hairy, button-like seeds of an orange-like fruit of Strychnos Nux-vomica, a small, irregular tree native of the savanna forests of India, Ceylon, Cochin-China, and northern Australia.[1] The large fruits contain from three to five of these greayish flat seeds which are very hard and bitter.

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[1] Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 274.

Nux-vomica occurs abundantly at present in the lower mixed forests of the tropical districts having a periodially dry season, in southeastern Asia and northern Australia.[2] The Gorakhpur forests of India as well as those of the Coromandel coast of India,[3] the eastern slopes of the Pegu Yoma Mountains in Burma,[4] Ceylon, and northern Australia, particularly Queensland, are regions where Nux-vomica is commercially important.

The ripe seeds of Strychnos Nux-vomica contain two important alkaloids, strychnine and bucine. The former is used in medicinal products in small doses, as a tonic, and in the treatment of nervous disorders and paralysis. Exports of these seeds is chiefly from India, Ceylon, and Queensland in Australia.[5] The United States is an important customer, having purchased 2,885,450 pounds of these seeds for medicinal purposes in 1935.[6]

Cutch. The term cutch (or catechu) is the name applied to a dried extract used chiefly for dyeing purposes. This dried extract is derived from the heartwood of a moderate to large-sized tree, Acacia catechu, which is common in most of the dri-

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2 A. F. Wilhelm Schimper, Plant Geography, The Oxford Clarendon Press, 1903, p. 353.

3 Ibid., p. 474.

4 Ibid., p. 474.

5 William G. Freeman and Stafford E. Chandler, World's Commercial Products, Ginn and Company, 1911, p. 339.

6 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 278.

er forests (savanna)[7] of India, Burma, and Ceylon. This tree grows on dry stony calcareous soils[8] and in pure sands along the sandy beds of streams in the sub-Himalayan tract.[9]

Chips of the heartwood are boiled in water and then the dark-colored extract is evaporated down to a purplish-black, gummy, semi-solid substance which is molded into blocks or cakes and wrapped in palm leaves for export.

In 1935 the United States imported 249,850 pounds of this extract.[10]

The dye from Acacia catechu is strictly fast and is used for various brown, fawn, olive, and drab colors, including our familiar khaki. Cutch is also used as a masticatory and in medicine.

Red Sandalwood. Pterocarpus santalinus, a moderate-sized East Indian tree, is the source of a blood-red dye, known commercially as red sandalwood or red sanderswood.

This savanna forest tree [11] occupies a limited region in the dry hills of the eastern Deccan, from the Godavari to the

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7 A. F. Wilhelm Schimper, Plant Geography, The Oxford Clarendon Press, 1903, p. 298.

8 Ibid., p. 380.

9 Raphael Zon and William N. Sparhawk, Forest Resources of the World Vol. I, McGraw-Hill Book Company, Inc., 1923, p. 430.

10 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 145.

11 A. F. Wilhelm Schimper, Plant Geography, The Osford Clarendon Press, 1903, p. 298.

Palar Rivers.[12] Here the supply of trees is limited but capable of expansion should the demand for it arise. Other regions of occurrence of this tree outside of India are Java, the East Indies, Madagascar,[13] and China.[14]

Kadaya Gum. A colorless gum which has become very important in recent years is yielded by various Indian trees, and is known by any one of a number of names--kadaya, karaya, katira, or kuteera. The chief sources of this gum are these two trees, Sterculia urens and Cochlospermum gossypium.[15]

Sterculia urens is common in the dry deciduous forests of the sub-Himalayan region, from the Ganges eastward into Burma. It also occurs in the dry deciduous forests throughout the Indian peninsula, and on the hills of Rajputana, Central India, and Behar.[16]

Cochlospermum gossypium occurs in the sub-Himalayan tract from the Sutley to the Sarda Rivers, in Behar, Bandelkhana, Central Provinces, Deccan on the east side of the peninsula of India. These trees also grow in the dry regions of the Irra-

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12 Dietrich Brandis, Indian Trees, London-Archibald Constable and Company, Ltd., 1906, p. 240.

13 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1927, p. 418.

14 Charles R. Toothaker, Commercial Raw Materials, Ginn and Company, 1927, p. 183.

15 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 170.

16 Dietrich Brandis, Indian Trees, London-Archibald Constable and Company, Ltd., 1906, p. 80.

waddy Valley, the Malay Peninsula, Cambodia, and Ceylon.[17]

Several million pounds of kadaya gum are imported by the United States annually from India. In 1935 imports reached 4,829,884 pounds.[18]

Kadaya gum is used chiefly in the cigar, paste, and ice-cream industries.

Shea-Butter. One of the greatest sources of cheap vegetable oils in the tropics is shea-nuts, the seeds of Butyrospermum parkii, an African tree.[19] The seeds of the large fruit of this tree furnish the shea-butter, a greenish-yellow fat with a pleasant odor and taste.

The shea tree is a native of western tropical Africa. At present it grows chiefly in the tropical savanna forests of western Africa--in French Guinea, Portuguese Guinea, the hinterlands of Liberia and Nigeria--and the savanna country of Uganda and the Anglo-Egyptian Sudan.[20]

The large fruits of the shea tree are gathered by the natives. The grayish tallow is obtained by crude native methods right in the forests. The "nut" or seeds are removed from the fruits, roasted, and then ground on a grinding stone into a

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17 Dietrich Brandis, Indian Trees, London-Archibald Constable and Company, Ltd., 1906, p. 39.

18 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 170.

19 Otis W. Barrett, Tropical Crops, The Macmillan Company, 1938, p. 327.

20 Ibid., p. 327.

black paste which looks like asphalt, and then is boiled to separate the "butter".[21] The tallow or "butter" is solidified into cabbage-shaped balls, wrapped with large green leaves and sent down to the coast. Here the "lumps" are pressed into hogsheads and shipped to Europe for sundry purposes. As yet little has been done with the export of dried "nuts".

The better grade of shea-butter is edible, and is also used mixed with, or as a substitute for, cocoa butter in chocolate manufacture. Inferior grades find use in the making of lard, soaps, and candles.[22]

The production of shea-butter could be greatly increased if the demand occasioned it. In French West Africa alone it is estimated that 500,000 tons of shea-nuts go to waste every year, half that amount in Nigeria, and as much more in the remaining African regions of production.[23]

Divi-divi. Tannin extract known as divi-divi is obtained from the dried, twisted seed pods of Caesalpinia coriaria, a small legume tree which is native to the West Indies, Mexico, Venezuela, and northern Brazil. The pods are very thin, smooth, coffee-colored, about two to three inches long and three-

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21 Homer L. Shantz, Agricultural Regions of Africa, Economic Geography, XVII (1941), p. 228.

22 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 222.

23 Otis W. Barrett, Tropical Crops, The Macmillan Company, 1938, p. 327.

fourths of an inch broad, with a tendency to assume a double curve resembling the letter S when dry; the tissue of the seed pods contain the high percentage of tannin, averaging about forty to fifty per cent. Though the wood contains tannin, it is secondary to the seed pods.

The principal areas of present geographical distribution of divi-divi include those of which this tree is native: the Pacific Coast states of Mexico and Central America; the leeward side of the West Indian islands of Cuba, Jamaica, and Haiti;[24] the Goajira Peninsula of Colombia;[25] the Segovia Plateau of northern Venezuela[26] and the region around Lake Maracaibo; the Guianas; and northern Brazil. Mexico is generally assumed as having the greatest natural supply, but there are no exact or complete statistics to substantiate this fact.[27] The divi-divi pods which enter into commerce come mainly from Venezuela. Outside the Caribbean area small scale cultivation has been introduced into Java, India, and Australia.

Divi-divi trees are found only in regions of the Monsoon Tropical climate where the vegetation is typically tropical savanna. The tree requires hot, semi-arid conditions with

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24 Donald D. Brand, Divi-divi and Sesame in Mexico, Economic Geography, XVII (1941), p. 142.

25 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 573.

26 Ibid., p. 636.

27 Op. cit., p. 142.

heavy summer rainfall and nearly dry winters.[28] It thrives best in sandy waste plains at fairly low elevations, anywhere from sea level to altitudes of three hundred feet.

In most regions of the Caribbean the trees grow wild in native forest patches; the divi-divi pods are gathered as part of a forest-collecting industry though several small plantations have produced well in Venezuela, near Marac and Cumana.

The pods are harvested by the natives, being collected in January or February. The pods are allowed to ripen on the tree and then fall to the ground where they are collected by raking them off the ground, winnowing out the dirt and trash. Then the pods are split open and the husks, similar to pea pods, are spread out in the sun until they become hard, brown, and dry.[29] Pods are prepared for market either by placing the dried ones into sacks for shipment on burro-backs, or tied into bundles, and exported in that form. Where tannin extract is to be made locally, the pods and seeds are normally pulverized and sifted, and the resulting powder is added to water in vats to form the tanning liquor.

The trees produce their first pods in seven years and bear for one hundred years or more. One tree averages one hundred pounds of dried pods (or about thirty-three pounds of tannin), but the exceptional trees will yield more than three hundred

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[28] Donald D. Brand, Divi-divi and Sesame in Mexico, Economic Geography, XVII (1941), p. 142.

[29] Ibid., p. 143.

pounds.[30]

The tannin from divi-divi pods is very cheap.[31] In spite of this, only a small amount is used in the United States (88,096 pounds were imported in 1935);[32] but divi-divi is very popular in Europe. Its use in the United States is not as yet very extensive because of numerous other extracts which are available; but since the American chestnut supply is rapidly being depleted by cutting and blight, and rather than develop hemlock, oak, sumac, and canaigre in western United States, imports of this tannin are increasing.[33] Venezuela and Colombia are the largest exporters, followed by Netherlandish West Indies, Dominican Republic, and Mexico.[34] Exports are chiefly from Caracas and Maracaibo to Germany, France, the Low Countries, and the United States.[35] Germany has been the chief market for divi-divi for over a hundred years.

Myrobolans. Myrobolans (or myrobolan nuts) of commerce refer to the dry unripe fruit of several species of Indian

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30 Op. cit., p. 143.

31 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1927, p. 84.

32 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 170.

33 Donald D. Brand, Divi-divi and Sesame in Mexico, Economic Geography, XVII (1941), p. 144.

34 Ibid., p. 144.

35 Ibid., p. 144.

trees of the Terminalia genus which furnish one of the best tannin materials known. The two most common trees and the ones which constitute the great source of this supply is the Terminalia chebula and Terminalia bellerica, trees usually from forty to sixty feet in height.[36]

These trees are common in the deciduous savanna forests[37] of the tropics throughout the peninsulas of India and Burma, and is also found in the same forest type of Ceylon. The tree does not grow in either the arid region of the Sind, or western Rajputana, or southern Punjab.[38] The sub-Himalayan forest tract, up to elevations of 5000 feet, which extends from near the Indus eastward[39] is the chief region furnishing the myrobolans of commerce.

The unripe fruits--known as "lean greens"--are richer in tannin than the ripe fruits, having a tannin content of from thirty to forty per cent. Neither the stones or kernels contain the tannin; the tannin exists in the pulp which surrounds the kernel and is not very easily extracted.[40] The unripe fruits are harvested by the natives prior to the time of ripen-

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36 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 140.

37 A. F. Wilhelm Schimper, Plant Geography, The Oxford Clarendon Press, 1903, p. 353.

38 Dietrich Brandis, Indian Trees, London-Archibald Constable and Company, Ltd., 1906, p. 308.

39 Ibid., p. 308.

40 Liberty H. Bailey, Cyclopedia of American Agriculture Vol.II, The Macmillan Company, 1907, p. 627.

ing which occurs from October to January, and are placed in storage houses where the fruit shrivels up into irregular and wrinkled forms--hence the term "nuts". The nuts in good condition should be completely free from moisture as their absorptive properties are very great. The periodically dry period in the Monsoon Tropical climate coincides with the harvesting of the fruits and is of assistance in drying the nuts thoroughly for export.

Both the nuts and extract are exported, but because of the difficulty in extracting the tannin, the nuts are more commonly exported than the extract. The extraction of the tannin is done at importing centers which have the facilities for this process. The chief export center for myrobolans is Bombay[41] from which large quantities are sent to European markets and the United States.[42]

The United States imports both the nuts and the extract. In 1935 the imports of nuts reached 27,498,240 pounds, while that of myrobolan extract was only 2,957,613 pounds.[43]

The myrobolan extract, if used alone, yields a spongy leather of a light yellow color; but in combination with other

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41 Dietrich Brandis, Indian Trees, London-Archibald Constable and Company, Ltd., 1906, p. 308.

42 Clarence F. Jones, Economic Geography, Henry Holt and Company, 1935, p. 250.

43 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 140.

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41 Dietrich Brandis, Indian Trees, London-Archibald Constable and Company, Ltd., 1906, p. 308.

42 Clarence F. Jones, Economic Geography, Henry Holt and Company, 1935, p. 250.

43 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 140.

tanning materials--quebracho or hemlock bark--it is more satisfactory. Tannin from myrobolans is used with calf, goat, and sheep skin, and for sole and harness leather.

CHAPTER VIII

TREE CROPS OF THE COOL TROPICAL HIGHLAND CLIMATE

There is but one tree crop of prominence within the tropical plateaus of the world--coffee. Temperate fruits of cooler regions--peaches, pears, plums,--can be grown in this climatic regime.[1] However, when grown here, they are of poor quality because they lack the influence of winter conditions which are needed in order for them to do their best. Though these fruits are raised, none are important to any extent commercially. This climatic zone is, therefore, the "coffee pot" of the world.

Coffee. Of the non-alcoholic beverages--coffee, tea, cocoa--coffee ranks first from a commercial standpoint; this is so in spite of the fact that more people drink tea.[2]

The use of the seeds of the coffee berries as a beverage probably originated on the plateau of Ethiopia (Abyssinia) where the tree is indigenous. From Ethiopia its cultivation was carried to Arabia about five hundred years ago, and for two centuries Arabia supplied the world with coffee. Gradually the

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1 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 264.

2 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 429.

tree was introduced elsewhere within the tropics, reaching Java and Ceylon by 1700, the West Indies in 1720, and Brazil, 1770.[3]

Coffee belongs to the genus Coffea. Only three of the twenty-five species are of commercial importance. Coffea arabica, native to Ethiopia, is the source of 90 per cent of the world's supply.[4] Coffea robusta is more hardy and is, therefore, adapted to a wider range of climate. About 85 per cent of the Java crop is of this species which is believed to be a native of the Congo region of Africa. Its quality is not as good as that of Coffea arabica. Coffea liberica, a native of the west coast of Africa, is more vigorous and less susceptible to disease. Because the flavor and aroma are inferior, this coffee is used chiefly in blends.

The chief areas of coffee production have shifted with the years, but has always remained in the tropics. At first Arabia led, but then was replaced in turn by the West Indies, Java, and Brazil. Because of certain advantages the tropical uplands of southeastern Brazil, a highland region which slopes westward from the Coast Ranges toward the Parana River in the interior, today stands preeminent as a coffee producer and furnishes over 70 per cent of the world's supply.[5] The highlands of the Car-

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[3] Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 498.

[4] Ibid., p. 498.

[5] Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1936, p. 432.

ibbean region--Colombia, Venezuela, Guatemala, Salvador, and Haiti--are next to Brazil in importance, producing nearly two-thirds of the export outside of Brazil. The Dutch Indies, Arabia, and small areas in Africa produce about one-fourth of the export coffee. Excellent coffee grows in the mountains of eastern Java and western Sumatra.

The coffee tree (Coffea arabica) is distinctly tropical in its requirements, requiring a hot, moist climate. The coffee-producing lands are thereby restricted to regions between 25° North Latitude and 25° South Latitude. Coffee requires much moisture, at least an annual rainfall of 45 to 60 inches through the year, and prefers 75 to 120 inches.[6] Less rainfall, however, is desirable during the blossoming, ripening, and harvesting of the coffee berries. Frequent showers during every month of the year should prevail, since these trees have no real rest period. Heavy fogs and night fogs during a relatively drier season have beneficial effects upon the growth of coffee trees. Prolonged periods of drought cause unripe berries to drop. Because mountain slopes within the tropics receive more precipitation than do many of the nearby lowland plains, they are preferred to the valleys as sites for plantations, for in addition to high rainfall here both the air and water drainage are more adequate.

Rich forest soils containing humus are necessary. The

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[6] Op. cit., p. 431

soils most favorable for coffee trees are those of volcanic origin,[7] where weathering is actively breaking down lavas and liberating the essential plant foods. The finest coffee lands of Brazil, Colombia, Central America, Mexico, Java, and Sumatra all have rich and deep loamy soils derived from young volcanism. It is said that on some of the best coffee lands in Central America and Brazil the loose mantle goes down 100 to 200 feet. This allows ample opportunity for root penetration.

Coffee can be grown from sea level to an altitude of 6000 feet, but does best at altitudes of 2500 to 6000 feet where average temperatures of the warmest and coldest months range between 82° F. and 55° F. respectively, where days may be quite warm--90° F. or more, but where temperatures at night may occasionally drop as low as 40° F. The moderate temperatures of the uplands decreases the need for shade which young trees require from the sun's vertical rays on the lowland plains.

Brazil's high place in coffee production has resulted from a favorable combination of physical and economic conditions: the broad, rolling plateau in southeastern Brazil, averaging about 3000 feet above sea level, provides an enormous coffee area, and permits use of modern machinery and cheap methods;[8]

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[7] Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 499.

[8] Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 125.

the terra roxa soils--a fine red clay, rich in humus and with deep gravel soil underlying it to give excellent drainage--are ideal for coffee trees; lying near the margin of the tropics at elevations between 1800 and 2500 feet give moderate temperatures which make it unnecessary to plant and care for shade trees, and also provides comfortable temperatures for the workers;[9] the rainfall (45 to 60 inches per year) comes mostly when the fruit is ripening and when the tree needs most moisture;[10] since these are newly cultivated lands as far as coffee production is concerned, having moderate temperatures, much sunshine, and a dry season, diseases characteristic of coffee plantations in the old-cultivated lands of the world are restricted;[11] a century of immigration has provided excellent cheap labor for carrying on the various phases of coffee production; and the location of Brazil's coffee estates at no great distance from Santos and Rio de Janeiro, Brazil's great coffee ports, with their excellent railway connections to all plantation districts, is a great advantage because Brazil exports most of its coffee.

It is because of these advantages which Brazil has that few regions can compete with her coffee production. Most of the other important coffee regions produce different kinds of coffee which are more aromatic or milder than Brazilian coffee,

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9 Op. cit., p. 127.
10 Ibid., p. 127.
11 Ibid., p. 127.

and so are particularly valuable when used to blend with Brazil's strong coffee.

The Caribbean coffee-producing countries have the advantage of steep mountain slopes between 1800 and 5500 feet to produce almost ideal physical conditions for coffee. These countries have dense populations of good workers.[12]

The islands of the East Indies--Java and Sumatra--have dense populations providing cheap, skilled labor, lie near the sea to give it advantage for transportation, and have very fertile volcanic soils.[13] Such conditions result in the production of excellent coffee there.

Under cultivation coffee is grown directly from seed, and seedlings are transplanted at six foot intervals. Shading, except at higher altitudes, and constant weeding are essential; catch crops are often grown. Trees begin to bear in the third year, but the best yield is obtained by the fifth. Coffee trees continue to bear for about thirty years.[14] Good bearing trees average two to four pounds per tree during the first twelve to eighteen bearing years. The yield varies with environmental conditions, anywhere from 200 to over 1000 pounds per acre.

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12 Op. cit., p. 129.

13 Ibid., p. 129.

14 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 500.

In some localities coffee is produced on small patches cultivated by the natives, as in Java. In the more important coffee-producing regions, particularly in Brazil, the plantation method is employed. The so-called cooperative plan is followed in Brazil. Here the plantations are owned by wealthy men and worked by a community of workers who enjoy whatever profits they can make until the coffee trees are six years old. The workers may have whatever coffee is produced by the tree up to the sixth year; and they may plant "catch crops" among the young trees of the plantation for their own use.[15]

Harvesting is mainly by the hand method. Where the plantations are on level land the ripe berries are shaken, beaten, or pulled off by hand, either onto the ground or onto mats or sacking carpets, then scraped up, the rubbish sifted out, and dumped into boxes to be hauled down to the pulping and drying plant. Some estates even have canals, flumes, or pipes through which the berries are flumed down.

In Arabia and parts of Brazil the coffee berries are allowed to fall to the ground when ripe and are then gathered.[16]

After picking, the coffee is prepared for market by either the dry or the wet method.[17] In the former the berries are

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15 Charles C. Colby and Alice Foster, Economic Geography, Ginn and Company, 1931, p. 90.

16 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 500.

17 Ibid., p. 500.

spread out on drying floors and exposed to the sun, care being taken to protect them from the rain. The berries are constantly stirred so they will be dried uniformly. Eventually the dried skin and pulp are cleaned off by machines, and the parchment is removed by pounding in a mortar or by mechanical means. In the wet method the berries are put through a pulping machine which tears the fruit apart, removes the skin and part of the pulp, separating the seeds from the pulp in the process. The seeds are then placed in vats where the fermenting process removes the vestiges of pulp from them. Finally, the coffee beans are dried by the sun or artificial heat. After drying, the brittle parchment is cracked and removed by hulling machines, and the silver skins are rubbed off in polishing machines. The coffee beans are then graded and packed in burlap bags for shipment.

The United States leads in coffee consumption, using over half the world's supply. In 1935 the imports amounted to about 1,755,809,167 pounds, coming mainly from Brazil and Colombia.[18] Other large consumers of coffee are Sweden, Cuba, Denmark, Belgium, Norway, France, Germany, and the United Kingdom, in the order named. The high cost of coffee in Europe has tended to throw the trend there toward cacao preparation.

In more recent years Brazil has suffered from overproduction and low prices, and has attempted to restrict the industry

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[18] Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 501.

in all its phases, even using the surplus beans as fuel, fertilizer, and cafelite (a plastic).[19]

19 Op. cit., p. 501.

CHAPTER IX

TREE CROPS OF THE SEMI-ARID TROPICAL CLIMATE

The Semi-arid Tropical regions are lands of scanty rain which occur only from one to three months of the year, during which time the rains are light and often irregular. The rainfall averages from eight to twenty-five inches, depending upon the locality. Hence this climate supports but few trees, and in many areas trees are entirely absent; the dominant element of these regions is low grass. Nevertheless, five tree crops typical of this climate have attained commercial importance: gum arabic and wattle gum, tree gums; ceara rubber, a latex product; carnauba wax, a vegetable wax; and wattle bark, a tanning material.

Gum Arabic. Certain trees produce dried, gummy exudations which are soluble in water to form viscous sticky solutions. The most important of such commercial gums is gum arabic, a gum obtained chiefly from Acacia senegal, a small thorny tree which is a native of the arid portions of northern Africa.[1] Present production of gum arabic is largely from this species of Acacia which occurs in dry sandy regions through the Sudan of Africa, in the belt which stretches across Africa south of the Sahara

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[1] Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 168.

to include the hinterland of Senegal, Senegambia, northern Nigeria, and Morocco of West Africa, and Anglo-Egyptian Sudan, Ethiopia (Abyssinia), and Somaliland of the horn of East Africa. Other species of Acacia produce gums similar tc gum arabic in semi-arid tropical regions of Arabia, Australia, India (in the Sind and the Northern Deccan), and in Cape Colony of South Africa.[2]

On the north bank of the Senegal River vast forests of Acacia Senegal occur, stretching away into the hinterland. This region is inhabited by the Moors and other wandering peoples who employ their slaves in the collection of gum. In Senegal and Gambia or its hinterland no system of cultivation is attempted. During the rainy season the forests are converted into swamps, and the trees become gorged with sap. After the rains cease, the scorching east wind known as the Harmattan prevails during the dry season, and this rapidly removes the excess of water; the barks of the tree become fissured in all directions and through these fissures the gum exudes as a thick liquid which rapidly dries into "tears".[3]

The world's supply of best quality of gum arabic is obtained from the Anglo-Egyptian Sudan, chiefly in the province of

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2 Dietrich Brandis, Indian Trees, London-Archibald Constable and Company, Ltd., 1906, p. 264.

3 William G. Freeman and Stafford E. Chandler, World's Commercial Products, Ginn and Company, 1911, p. 347.

Kordofan.[4] Here the gum is known by such names as Sudan gum, Kordofan gum, and hashab gum. Acacia Senegal is extensively cultivated in this region. Here, the trees are grown in groves called "genenas". The trees are raised from seed, and begin to exude gum in the third year of growth when they are eight to ten feet in height. They continue to produce gum until the fifteenth year when it is advisable to renew the grove. The best yields are obtained from the eighth to twelfth years of growth.[5]

Trees cultivated in these groves are tapped between February and May. Transverse incisions are made with a small ax and thin strips of the outer bark are torn off. The gum slowly exudes as a viscous liquid, collects in a drop, and hardens. After three to eight weeks these small lumps, called "tears"--up to half an inch or an inch in diameter--are collected.[6] Then these "tears" are bleached white by being exposed to the sun on the banks of the Nile. The colorless "tears" fetch higher prices in the world markets than do the unbleached which are yellow or reddish in color. Kardofan or hashab gum is exported from Cairo and Port Said.

Because gum arabic is slowly soluble in cold water and has a high degree of adhesiveness and viscosity, much of it finds

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4 Op. cit., p. 345.
5 Ibid., p. 436.
6 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 168.

use in the textile, mucilage, paste, polish, and confectionery industries, and as glaze in painting. It also is used in medicines. Imports by the United States for such uses amounted to 7,954,840 pounds in the year 1935.[7]

Wattle Gum. (See the discussion under Wattle Bark on page 284).

Ceara Rubber. The only latex-producing tree outside the region of the Tropical Rainy climate is the Manihot glaziovii, a small tree with xerophytic adaptations which furnishes what is popularly called ceara rubber. Manihot glaziovii is native to the arid portions of the western part of the provinces of northeastern Brazil; and here the climate is one marked by a long dry season and a short wet season characteristic of the Semi-arid Tropical climate.[8]

Manihot glaziovii is an important tree growth in the western parts of the Brazilian provinces of Ceara, Pernambuco, Parahiba,[9] and here it furnishes a not unconsiderable quantity of rubber.[10] This region of Brazil is covered with dry rocky ground and so can be utilized for growing a rubber-producing tree, the only type which will thrive in semi-arid regions.

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[7] Op. cit., p. 193.

[8] Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 62.

[9] Ibid., p. 51 (map).

[10] Ibid., p. 62.

Those parts of Ceylon and India having a long dry season and a short wet season now also grow this rubber-producing tree.[11]

The tree grows very rapidly, reaching its maximum height of thirty feet in a very few years. The Manihot trees are tapped when four to five years of age, and yield a good grade of rubber. The latex is coagulated by exposure to air or smoke. The crude rubber is exported as blocks or cakes.

Carnauba Wax. The carnauba palm yields the most important vegetable wax of commerce.[12] The wax occurs as a protective coating on the leaves of the carnauba palm (Copernicia derifera), a tree native to arid northeastern Brazil.

The entire commercial output of carnauba wax comes from the drought region of northeastern Brazil which lies between the Paranhiba and São Francisco Rivers. Approximately 50 per cent of the producing palms are found in the two states of Ceara and Piauhy, while the other half are widely scattered through the adjoining states of the northeastern region--Rio do Norte, Parahiba, Pernambuco, Alagoas, and Serijipe.[13] The favorite habitat for this palm is the broad, dry valleys or along the river banks within the area. It is not surprising to find extensive areas of carnauba palms in pure stands here--

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11 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 158.

12 Ibid., p. 225.

13 Warren Strain, Carnauba Wax: Brazil's Monopoly Product, The Journal of Geography, XLI (1942), p. 124.

a characteristic not common among tropical plants--along the Jaguaribe R., the Paranhiba R., and the São Francisco R. since this palm avoids the highlands and hilly country. Some attempts have been made to develop plantations, but it is yet too soon to predict results.

The character of the climate of this portion of Brazil favors the development of this palm and its product--wax. This limited portion of northeastern Brazil has a Semi-arid Tropical climate--a short rainy season with variable rainfall and a fairly long, well-defined dry season, both accompanied by high temperatures. During the wet season--between December and early May--the carnauba palm absorbs a great quantity of water which it requires to carry on its life functions. To protect the palm from excess evaporation during the dry season which follows, nature has provided a protective covering of wax which becomes heavier if the dry season is more prolonged than usual. Thus, without a well-defined drought period the carnauba palm would be worthless as a producer of wax.[14]

The carnauba palm grows wild in pure stands on large tracts of land under individual ownership. The collecting of the leaves for their wax provides a forest-gathering industry of a highly advanced type. One of three systems may be used:[15] the

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[14] Warren Strain, Carnauba Wax: Brazil's Monopoly Product, The Journal of Geography, XLI (1942), p. 124.

[15] Ibid., p. 125-126.

wax may be harvested by the share-cropping system; the palm groves may be rented by the collectors from the owners to whom they sell the wax at the close of the harvesting season; or collectors may be hired to collect and prepare the wax for market.

Carnauba palms seven to ten years old are ready for the first harvest. The harvesting season begins about a month after the beginning of the dry season (August), to allow time for the leaves to exude a considerable quantity of wax, and the harvesting usually lasts until January or February when the wet season begins. Three cuttings are usually made during the harvesting period, at intervals of ten to twelve weeks--ten leaves being taken the first time, and five each the last two times in order to maintain the tree's production of wax from year to year.[16] Skilled labor is needed for proper selection of leaves at the time of cutting. The maximum wax is found only in those young leaves maintaining a position parallel to the ground, and these are cut with hatchet-like knives.[17]

After the long stems have been removed from the leaves (since they contain a negligible quantity of wax), the blades of leaves are exposed to the tropical sun in the drying fields for three to four days for thorough drying, causing the leaves to wilt and shrink. By this shrinking action the wax becomes

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16 Op. cit., p. 126.

17 Ibid., p. 126.

loose and is easily removed. During drying the leaves must be protected from strong winds which might cause the loss of considerable quantities of wax dust. Threshing, in which the leaves are shredded to release the wax in inaccessible parts of the leaf, follows. Finally, the wax and wax dust are melted, solidified into cakes, graded, and packed, ready for shipment.

Approximately two-thirds of Brazil's total export of wax comes to the United States. Imports of carnauba wax in 1935 amounted to 10,420,568 pounds.[18] Because this wax is hard and has a high melting point, it is used in the manufacture of candles, high luster wax varnishes and polishes, phonograph records, artificial fruits, vegetables, and meats for display purposes, as a luster-producing filler in the textile industry, and picric acid which is used in the manufacture of explosives.

Wattle Bark. This is considered one of the most important tanning materials of the future because of its quick growth, attaining commercial value in seven years, and yielding a bark containing 35 per cent tannin, whereas the domestic oak reaches its maximum of 12 per cent tannin at the age of fifty years, and hemlock, at eighty years.[19] One acre of wattle trees after seven years of growth contains the same quantity of tannin as

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[18] Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 227.

[19] Wilbur J. Page, Tanning Materials Survey, Trade Information Bulletin No. 167, Bureau of Foreign and Domestic Commerce, 1924, p. 4.

eighteen acres of oak trees which have reached the age of maturity--forty to fifty years.[20]

Wattle bark, which is rich in tannin, as well as wattle gum are both obtained from a group of acacias which are indigenous to the semi-arid regions of southern Australia and now largely cultivated on plantations in Natal in South Africa, Tanganyika, Kenyon, and Ceylon.[21]

The climatic, labor, and soil conditions together with transportation facilities were so favorable in South Africa as compared with Australia that the Australian tanning industry is supplied with wattle bark from Natal where the industry is one of the mainstays of Natal's progress.[22]

In Australia wattle production is from native trees which grow scattered in the steppe regions in New South Wales and South Australia. Little attention has been paid in Australia to the cultivation of wattles on plantations, but in Natal with its summer rainfall and mild winters it is done on a large scale. Here the cultivation dates back to 1880 and has come to be regarded as one of the most important of the minor forest industries of South Africa.[23]

In Natal two species of acacia are most commonly grown,

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20 Op. cit., p. 10.

21 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 327-8.

22 Op. cit., p. 3.

23 Ibid., p. 3.

Acacia mollissima and Acacia dealbata, having been introduced from Australia. Acacia pycnantha and Acacia decurrens are also of commercial importance. In both the southern parts of Australia and Natal the trees are largely cultivated for their bark, the soluble gum known as wattle gum being collected from them as a by-product.[24]

The climatic requirements of wattle trees are such that wattle culture of the future need not necessarily be restricted to the Monsoon Tropical climate. A rainfall of thirty to forty inches per annum is regarded as most propitious, but if the soil is deep and porous, a rainfall of even twenty inches will suffice. If moisture is otherwise available--around springs or along courses of rivers--rainfall is immaterial. A continously misty atmosphere is deemed favorable. Wattle trees thrive best on deep red soils produced by the disintegration of dolerite, but they will grow on other soils which are deep and well-drained.[25] Though no commercial plantations of wattle exist in the United States, the tree has been most successfully grown in California where climatic requirements are favorable. Arizona, New Mexico, eastern Texas, and Florida have districts possessing characteristics essential to profitable wattle culture.[26]

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[24] H. M. Hoar, Wattle Culture, Trade Information Bulletin No. 211, Bureau of Foreign and Domestic Commerce, 1924, p. 13.

[25] Ibid., p. 19.

[26] William G. Freeman and Stafford E. Chandler, World's Commercial Products, Ginn and Company, 1911, p. 347.

Where cultivated, these trees are grown from seed. Very little care except weeding is required by the young tree plants until they are about three feet high, when the lower branches should be pruned off so that a straight, even trunk from which the bark can easily be detached may be grown. Bark may be collected from the time the trees are five years old; but the richest bark is obtained from trees seven fo fifteen years old.[27] An acre of wattle trees seven to fifteen years old will yield six tons of bark;[28] and two and one-half tons of bark produces one ton of commercial wattle.[29]

In Natal the bark is collected in September or December, for during those rainy months the bark is richest in tannin. After being stripped from the trunks of the trees, the bark is merely dried in the sun and then is either cut into small pieces to facilitate handling in shipping, or may be ground to a coarse powder. An extract is also available.

Wattle bark is largely used in the United Kingdom for tanning sole leather. It yields a firm, solid leather with a faint pink tint. Though used chiefly in Great Britain, wattle is of steadily increasing prominence in this country.[30] Imports are

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27 Op. cit., p. 352.

28 H. M. Hoar, Wattle Culture, Trade Information Bulletin No. 211, Bureau of Foreign and Domestic Commerce, 1924, p. 23.

29 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 328.

30 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 137.

largely in powder form, but some extract is also among the imports. Our imports in 1935 of the former reached 17,439,510 pounds, while that of the latter was only 4,733,732 pounds.[31]

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31 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 137.

CHAPTER X

TREE CROPS OF THE ARID TROPICAL TYPE OF CLIMATE

One tree crop--the date--is representative of oases in the Arid Tropical regions of the world. Though other tree fruits, as pomegranate, apricot, olives, and even peach, may be found along with dates in this climatic type, they are only of minor importance here, having been introduced from the subtropical regions. The date is the dominant tree in oases of the tropical deserts and is "king of tree crops" there.

The Date. The date is perhaps the oldest known cultivated fruit in the world, going back at least 5000 years. The date palm, the tree from which the fruit is obtained, is probably a native of the oases in the hot dry deserts of southern Asia (Arabia and India), but has long been domesticated throughout southwestern Asia and northern Africa. It was in Arabia before the dawn of history, was of great importance in Babylonia, and had reached Egypt long before the Christian era. In all places it has been, and still is, a tree of the oasis rather than of the desert proper.

The date is the fruit of the palm (Phoenix dactylifera). The fruit grows in large clusters near the top of this palm tree. Each individual fruit, from one to three inches long and slender, is a nearly round drupe, or one-seeded berry, is hard

and green at first, but later turns yellow or red. The thick flesh is very sweet, soft, or dry and hard, depending on the variety.

Centers of large scale production of dates have remained in the East despite its spread from southern Asia across Africa, and much later to deserts of Mexico, Peru, and southwestern United States.

The Shat-el-Arab Oasis in the fertile irrigated lowland along the Tigris and Euphrates Rivers in Iraq (Mesopotamia) produces 80 per cent of the world's commercial crop.[1] This region contains not less than twenty million palms under cultivation and supplies most of the American market. Date cultivation by the Arabs is most scientifically carried on in the Somail Valley of Oman in eastern Arabia where alone the Fardh dates of commerce are produced.[2]

The oases of the Sahara Desert in North Africa--Tunisia, Libya, and Algeria--produces the world's finest dates, and these are exported not only to Europe but to the United States.[3] In Egypt there are nearly ten million palms of which seven-tenths are widely scattered in upper Egypt.[4] Morocco grows good dates in the Tafilalet Oasis only, where huge fruits of the Majhul

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1 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 200.

2 Ibid., p. 200.

3 Ibid., p. 200.

4 Ibid., p. 200.

variety are shipped to England and Spain.[5] In French West Africa dates make up the principal crop of the scattered oases and constitute the chief cash crop available for commercial purposes.

The warmer and drier parts of the other Mediterranean lands, especially Turkey, Italy, and France, have some date cultivation. Serious attempts to put the date industry of northwestern India on a sound basis are being made, and with good prospects of success. Intelligent cultivation is now being attempted in some parts of Brazil where it promises to attain commercial importance.[6]

Dates have been grown in California since the eighteenth century, but have been commercially important there only since 1890. In the Imperial Valley of California and limited portions of deserts of Arizona and New Mexico conditions are particularly favorable. Arizona and California offer best fields for date growing in the United States. In 1935 about 6,506,000 pounds were produced by these two states.[7]

All regions of date cultivation fall either within the oasis of the Arid Tropical climate or in the drier parts of the Mediterranean Subtropical regions of the northern hemisphere.

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[5] Op. cit., p. 200.

[6] Ibid., p. 200.

[7] Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 444.

In the former it is a part of an old plantation industry largely for local use, while in the latter it is a scientific plantation industry where production is largely for commercial purposes.

Optimum climatic conditions for date production are present in desert oases having the following:[8] high yearly temperatures combined with low humidity; long summers; combination of hot days and hot nights; an abundance of sunshine; an absence of rain in spring when the fruit is setting; an absence of rain or dew in the fall when the fruit is ripening; from five to fifteen inches of rainfall a year, irrigation, or source of underground water. Dates require less rain than any other tree crop. Rainfall during the pollination period prevents the fruit from setting; at the time of maturation it causes fruit to ferment. Even morning dew may cause fermentation so where there is this danger the fruit must be protected by some type of bagging.

No one soil type can be asserted necessary.[9] Stiff clays of the Tigris-Euphrates delta, adobe soils of Egypt, the sandy type of Algeria, and the sandy loam of Oman and California all support date palms. Typical sandy oasis soils which never seems to wear out are advantageous to the date industry because no other tree will thrive in it. Soil of adequate fertility is

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8 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 202-203.

9 Ibid., p. 203.

absolutely necessary to produce fruit heavily for commercial purposes. Therefore, nitrogen-gathering cover crops are much in favor in scientific plantation farming. Saline or alkaline soils are tolerated.

Date palms grow readily from seed or cuttings. Now they are propagated almost entirely by offshoots which sprout from the base of the trunk. These have the advantage over seedlings which require a waiting period of five to six years, and then the fruit of most seedling trees is almost inedible.

One of the problems involved in date palm culture is that of the pollination of the trees. Male and female flowers of the palm occur on separate trees so that a few male trees are needed to furnish pollen for the female trees--averaging one male tree to fifty female trees. In order to fertilize the blossoms, a spray of the flowers of the male palm is fastened with a thread of a palm leaf in each group of blossoms on the female tree; or pollen from the male trees is dusted onto the blossoms of the female tree.

During the period when the fruit clusters are ripening, danger from early morning dew necessitates nightly covering with moisture-proof, pouch-like sacks.

If properly cared for, the date palm begins to bear in the fourth year, and should yield considerable return in the fifth and succeeding years. The greatest crop occurs between the thirtieth and fortieth years. The trees furnish one crop per

year, yields lasting for a period of forty years. When the tree reaches fifty years of age, the crop begins to fail; at seventy-five to one hundred years the tree stops fruiting and then it is tapped to death for the sugar content. As much as 15,000 pounds per year may be obtained from an acre of date palms.

The time of harvest depends upon the locality. In tropical regions the dates ripen in July and August. In subtropical regions (California, for example) the fruits ripen in December. Bunches of fruit weighing twenty to thirty pounds each are usually harvested in the Old World plantations by boys climbing the trees, cutting off the bunches, and lowering them to the ground by means of rope. Only under favorable conditions does a whole bunch mature so evenly that it can be removed entire without loss. In many cases it is necessary to pick out different "threads" carrying the dates, and cut them separately, leaving those whose fruit is not mature for another day.

The dates are sorted for size and quality, dried in the sun or by artificial means, and packed into boxes for shipping. From Old World oases camel caravans transport them to the nearest port.

The American product as yet is only capable of supplying a limited market, so much is imported from Asiatic Turkey, Arabia, and Africa. These regions also supply the European countries.

Dates are a luxury food outside the areas of production, finding use as a table fruit, in jams, paste, cooking, and al-

coholic beverages. To the desert oases dwellers dates are a staple food; in addition to furnishing food it has been estimated that the articles that have been made from the date palm and the uses to which it has been put number more than eight hundred. Every part of the plant is utilized, and the fruits even serve as money.

CHAPTER XI

TREE CROPS OF THE HUMID SUBTROPICAL CLIMATE

The Humid Subtropical climate is an important contributor of tree crop products. The prevailing climatic conditions of abundant rainfall and moderate temperatures which are characteristic of this climate favor the growth of a wide variety of trees, both nature-willed and man-willed, in all but one of the areas which are under the influence of this climate--the conspicuous exception being the Argentine Pampa. Many species of broadleaved and evergreen trees--wild as well as cultivated--thrive in this climatic zone; and many of these furnish man with a wide variety of tree crops, providing him with beverages, dyes and pigments, fruits, resins, fixed and essential oils, tanning materials, and edible nuts. In addition, large-scale production of tender subtropical fruits for local sustenance as well as for distant markets are possible in certain portions of the Humid Subtropical climate, being favored by such factors as abundance of rainfall, short, mild winters, extensive areas of relatively cheap land, and proximity to markets which are easily reached by modern transportation facilities.

Though the tree crops discussed below do not represent all of those which exist in this climatic region, they are, however, the ones which contribute importantly to the present world economy.

BEVERAGES

Maté. Maté, yerba maté, or Paraguay tea, as it is variously known, is next to coffee, tea, and cocoa in importance as a beverage. This beverage is obtained from the holly-like leaves of a small native evergreen tree, various species of holly, but chiefly from Ilex paraguayensis[1] (South American Holly). This tree is a native of the Humid Subtropical climatic region of South America, the Atlantic Coastal Hilly Belt which is located mainly in southeastern Brazil, and extends into Uruguay and eastern Paraguay (east of longitude 57° 30').[2] Though species of Ilex are widely distributed throughout South America from Colombia to Argentina, Ilex paraguayensis is of greatest commercial importance in the forests east of longitude 57° 30'. This region includes the basin of the River Plata drainage system, from 18° South (Bolivia and Matto Grosso, Brazil) to about 30° South (Northern Uruguay and Corrientes Province, Argentina) with occasional occurrences on the Atlantic seaboard.[3] The present important commercial forests of Ilex paraguayensis, however, are found in southern Matto Grosso, central and west-

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1 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 291.

2 Raphael Zon and William N. Sparhawk, Forest Resources of the World Vol. II, McGraw-Hill Book Company, Inc., 1923, p.783.

3 C. R. Cameron, Maté: An Important Brazilian Product, Bulletin of the Pan American Union, 1929, p. 990.

ern Paraná, western Santa Catharina, and northwestern Rio Grande do Sul, all in Brazil;[4] and in eastern Paraguay, beginning about sixty miles east of the river of the same name; from northern Argentina the maté comes from the Territory of Misiones and the northern part of the Province of Corrientes.[5] Thus, southern Brazil is by far the chief producer of maté, with Paraguay, Uruguay, and northern Argentina contributing also to the mate supply.

The climatic conditions of the Humid Subtropical climate favor mate production. Maté requires heavy precipitation--from 40 to 60 inches[6]--fairly well distributed throughout the year, and high temperatures. Maté avoids the low, swampy lands which border streams, because this tree requires excellent drainage; for this reason the mate tree is not usually found along the great rivers within the belt which may vary from 10 to 30 miles wide, but prefers depressions in the foothills and mountains, at altitudes of from 1500 to 2500 feet above sea level.[7] The tree thrives well only on deep, fertile, well-drained, red soils. While the maté trees are young, a forest cover, preferably of Paraná pine, is necessary to protect the young

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4 Op. cit., p. 991.

5 Ibid., p. 990.

6 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 319.

7 Op. cit., p. 990.

trees from the hot sun.[8] Later, much sunshine combined with high humidity favors growth of the tree and its leaves.[9]

Transportation from the maté forests and plantations in the well-drained uplands over muddy roads to the river and railways presents a problem of this industry. In addition, a good supply of efficient labor skilled in cutting, drying, roasting, and packing maté is necessary for low cost production of high grade maté.

Formerly the gathering of maté leaves was a forest-gathering industry entirely from wild forest trees which occurred in mixed stands. More recently plantations have been established in Paraná State, in Paraguay and in Misiones.[10] Brazil has not yet developed commercial plantations of maté, practically all the maté there produced being as yet obtained from the groves of trees occurring naturally in its territory.[11] Cultivated maté will eventually form the bulk of production. A number of factors have led to the cultivation of maté trees in groves, among them increased demand for the product, high prices commanded by maté in the markets, and the desire to eliminate de-

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8 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 291.

9 Ibid., p. 319.

10 Edward W. Shanahan, South America, E. P. Dutton and Company, 1927, p. 165.

11 C. R. Cameron, Maté: An Important Brazilian Product, Bulletin of the Pan American Union, 1929, p. 990.

structive methods of harvesting.[12] Economic conditions hare are responsible for retarding its more extensive cultivation--small supply of efficient labor, poor methods of cutting, drying, roasting, inadequate transportation facilities, lack of equipment and organization to insure a high quality product, and competition with coffee in Brazil.[13]

For cultivation purposes maté can be readily grown from seed. Seedlings are transplanted from nurseries to the plantations in the forest. Among the Paraná pines the young plants find protection from the intense sunlight.[14] Greatest attention must be given to the plantation during the first three years of growth. After that the plantation receives little attention except for the removing of underbrush and some of the forest growth.

The first crop of maté leaves is ready within a year after planting, although the best yield is obtained from trees over four years old. There is one cutting season a year, lasting about five to six months, from May to September. Since the fully developed leaf is preferred, the harvesting season coincides with the annual period of repose. The time of gathering maté from the public forests is limited by law in both Paraná and

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12 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 291.

13 Ibid., p. 292.

14 Ibid., p. 320.

Santa Catharina to the period from May to October, and in Matto Grosso from January to September, although this is sometimes extended by contract with the principal renter of the maté forests to the whole year, excepting the flowering season.[15] For wild trees cuttings are allowed by law only once in four years; if carefully done the harvesting may be repeated at intervals of three years without permanent injury to the tree. A full grown tree (wild) will sometimes produce as much as 66 to 88 pounds of dry leaves from a single harvest.[16]

Harvesting consists of chopping off large, leafy maté branches bearing tender leaves, followed by drying them either in the sun or by roasting over a fire. To facilitate the drying process the leaves should not be harvested when damp, but should be cut when free of rain or dew, usually during the sunny hours from 8 A. M. to 5 P. M.[17] Then the bunches of dried leaves are packed into bags and hauled to the rivers or ocean ports on the backs of human porters or mules bound for the factory where large companies prepare the leaves for market by beating them from the branches (threshing) and then grinding them up to a coarse powder ready for consumption. Sometimes the leaves are cured for six months before being sent to the factory

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15 C. R. Cameron, Maté: An Important Brazilian Product, Bulletin of the Pan American Union, 1929, p. 991.

16 Ibid., p. 1002.

17 Ibid., p. 992.

for final preparations.[18]

Maté or Paraguay tea is most important as a stimulating drink, made by pouring hot boiling water over the dried leaves. This is the universal drink of 20,000,000 South Americans,[19] and the leaves are consumed in large quantities--as much as 200,000,000 pounds annually--in Paraguay, northern Argentina, southern Brazil, Uruguay, and Chile.[20] On account of the heavy consumption of maté in Argentina, only Brazil and Paraguay export the product in important quantities. Only small amounts go to Europe and North America, for the habit of maté has never developed much in these two countries. The United States imported 422,149 pounds of maté in 1935 as compared with over 86,000,000 pounds of tea in the same year.[21]

Tea. Tea, coffee's chief rival as a beverage, is used by fully one-half the population of the world. It is prepared from the dried leaves of the tea tree, Thea sinensis,[22] a broad-leaved evergreen, native to the hill and mountain slopes of southeastern Asia.

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18 Op. cit., p. 997.

19 Edward W. Shanahan, South America, E. P. Dutton and Company, 1927, p. 165.

20 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 436.

21 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 506.

22 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 117.

The geographic distribution of the tea tree is limited to areas where there is no cold season.[23] It is, however, tolerant of a wide range of warm temperatures, such as prevail in the tropical and subtropical regions. The tree finds in the tropical and subtropical districts of southeastern Asia almost ideal conditions for its culture, both as a subsistence and a commercial plantation crop; and the production of tea for the world market was until the outbreak of World War II concentrated in this part of the world.

The concentration of tea farming in this part of the world results from four especially significant conditions: 1) the tree is indigenous to many districts of the region; 2) environmental conditions of the chief farming districts are favorable; 3)there is an abundant supply of cheap, skilled labor; and 4) the market for the product is enormous.

The tea tree is moisture-loving, requiring a heavy rainfall distributed evenly throughout the year, particularly throughout the long, hot summer.[24] Conditions favorable to rapid growth must exist since the crop depends on the number of leaf pickings during a year. Heaviest crops occur in regions having the best-watered land, lands having an ample, dependable rainfall, greater than 100 inches a year, and where the air is constantly

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23 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 532.

24 Clarence F. Jones, Economic Geography, Henry Holt and Company, 1941, p. 177.

humid.[25] With such heavy rainfall a well-drained soil is a requisite. In regions of copious summer rains, hillsides provide the necessary drainage. Altitude of the slopes at which tea is planted is no barrier to production, provided the soil is rich in humus; tea grown at higher elevations is said to be better than that grown at sea level.[26] Some tea farms may be found up to 6000 feet.

The dominant factor limiting tea production to southeastern Asia is cheap labor,[27] for physical conditions favorable to the growth of the tree exist in many other parts of the world; but in most of them sufficient cheap labor is not available.[28] The plucking of the leaves is a task requiring considerable skill. Successful tea plantations, therefore, must be located where the density of population is high and the standard of living low.[29]

Thus, the environmental and economic factors together with that of historical development are responsible for the concentration of the tea industry of the world in the countries of the

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25 Op. cit., p. 132.

26 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 177.

27 Ibid., p. 176.

28 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 532.

29 Op. cit., p. 177.

eastern and southern part of Asia. Here the commercial cultivation of tea is confined to restricted localities in southern China, Japan and Taiwan, Java and Sumatra in the Netherland Indies, Ceylon, and British India.

China leads the world in tea acreage and production;[30] in this country it is grown chiefly as a home supply crop, but the surplus is diverted into channels of foreign trade. The tea-producing region is mainly between the north side of the Yangtze Valley and the northern rim of the Si-Kiang Valley where the tea is grown inefficiently on small gardens or patches, and is prepared for market by primitive methods. Environmental conditions here are suited for tea farming: the tea is grown on the less desirable slopes of the hillsides,--the food crops are planted on the better lands--the slopes providing the necessary drainage for the copious summer precipitation; the red soils, high in humus content, are the most suitable for tea growth, but wherever poor, stony soils are present the number of leaf pickings is decreased; the annual rainfall of 50 and more inches, most of which comes in summer with the monsoon winds, and the high temperatures during the middle of the growing season favor the flushing of the tea tree.[31]

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30 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 177.

31 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 535.

Japan has favorable factors for tea production, but the industry is hampered by the small area available in this densely populated country. In Japan tea farming is also largely confined to small patches or gardens of usually less than an acre in size, on the foothills and on high terraces. The industry is confined to the east and west sides of mountains of central and southern Japan, especially in southern Honshu, Shikoku, and Kyushu.[32] However, there are more tea gardens on the Pacific slopes of these islands, since this part of Japan has milder winters and receives considerably more rain from the monsoon winds than does the west coast.[33] The prefecture of Shizuoka in east central Japan supplies almost half the total tea crop of the country and about nine-tenths of the amount exported.[34]

The tea crop of Japan comes largely from the lower slopes and terraced uplands, as high as 6000 feet. Slopes with their deep, porous, subsoil provide the excellent drainage required by the tea tree, and the soils in general are red and high in iron, humus, and volcanic ash. The tea areas have an annual rainfall of 60 to 80 inches, the largest part of which falls in the summer. In contrast to China, tea gardens in Japan are carefully tended and scientifically managed.

Shizuoka's location in east central Japan near the sea and

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32 Op. cit., p. 536.

33 Ibid., p. 536.

34 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 180.

ocean highway aid exportation from this section. More than 98 per cent of the tea exported from Japan before World War II was sent to the United States and Canada, the larger amount to the United States.[35]

On the terraced slopes of northwestern Taiwan grows the tea which is semi-fermented and sold in the American markets as Oolong tea.[36] This famous Oolong tea was shipped primarily to the United States before hostilities opened between Japan and the United States. Rather deep, well-drained soil favors the growth of the tree. The annual rainfall of about 80 inches and a growing season of about 11 months permit several more pickings than in Japan. Most of the tea is grown in small patches, but large estates are being developed under Japanese influence and capital.

Java and Sumatra in the Netherland Indies have made a great success of scientific tea production during the present century. In Java most of the tea is grown intensively on steep slopes of volcanic mountains on the western part of the island, at elevations between 1500 and 3500 feet above sea level, thus providing excellent drainage for the trees.[37] The fertile volcanic soils give high yields of leaves. The tea district averages more than 150 inches of rainfall annually, and is fairly well-distributed

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35 Op. cit., p. 180.

36 Ibid., p. 180.

37 Ibid., p. 181.

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35 Op. cit., p. 180.
36 Ibid., p. 180.
37 Ibid., p. 181.

throughout the year. Frequent pickings are possible during most of the year because of the heavy rainfall and high temperatures, even at intermediate elevations. The great density of population aids the industry by supplying an abundance of cheap, skilled, intelligent labor.

In Sumatra tea plantations have developed in the Deli district on the northeastern coast of the island, at elevations from 1200 to 2400 feet.[38] This has become an important tea-producing area in recent years because of favorable physical conditions, location near the sea and ocean highways, and a fairly large supply of efficient but inexpensive labor.[39]

British India is the principal tea exporter of the world.[40] Most of India's tea areas are concentrated in three limited regions: Assam, Darjeeling, and Travancore.[41] Unlike tea farming in China, tea culture here is scientifically carried on on plantations and estates owned by corporations and under the supervision of expert European managers.

In Assam, India's greatest tea region, the tea estates are centered on the flat alluvial lands of the Brahmaputra and Sur-

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38 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 535.

39 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 181.

40 Op. cit., p. 534.

41 Op. cit., p. 182.

ma Valleys,[42] in the regions immediately south of the Assam Hills. The virgin soils here are deep and high in humus content. High humidity, heavy dews and morning fogs, annual rainfall of 100 inches or more over a nine month period, complete absence of dry winds, and continuously high temperatures favor the rapid development of a maximum amount of high-grade leaves.

Another important tea area lies west from Assam on the slopes of the Himalayas in the high Darjeeling district, in the so-called Dooars,[43] which some claim produces the world's highest quality of tea. Tea plantations here are chiefly located on steep slopes ranging from 3000 to 4000 feet in elevation. Heavy rainfall of about 120 inches and the location of plantations on slopes makes terracing necessary. Temperatures are moderate and so the tree grows slowly, but this factor leads to the production of a very high grade of leaf of special flavor, unequalled in other districts. The yields of leaf per acre, however, are only about half that grown in the lowland plantations.

In southern India the tea areas are mainly on the rainy west flanks of the western Ghats and the dissected tableland in Travancore, at greater altitudes than in northern India.[44]

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42 Op. cit., p. 182.

43 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 535.

44 Op. cit., p. 183.

Steep slopes and heavy rainfall (from 100 to 150 inches) necessitates terracing. Temperatures are continuously high throughout the year. Soils are deep red clays. No real unfavorable season interferes with the growth of the leaves, and picking can continue throughout the year.[45]

Ceylon turned from coffee production to tea farming in the late sixties and seventies of the last century following the destruction of the coffee plantations by blight. Tea plantations in Ceylon are located almost entirely on the hillsides in the south central area.[46] Some estates are at elevations of 7000 feet, but most are nearer 3000 feet. The area receives from 150 to 200 inches of annual rainfall which is fairly well-distributed throughout the year. Physical conditions combine to make this region one of the most productive in the world. Thousands of laborers are imported every year from the mainland to pick and prepare the tea.

The nature of planting and the methods of cultivation of the tea trees vary with different localities. The tea plant is propagated from seed or seedlings, except in Taiwan, where the lower branches are layered to form new plants. When ten inches high the seedlings go into the tea gardens, farms, estates, or plantations. The young seedlings are left alone for about a

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45 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 535.

46 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 183.

year and a half; then they are topped back to induce a good number of side branches. Pruning of the bushes which form occurs two to three times a year to throw out numerous ascending branches. The tea tree is kept waist high to facilitate leaf plucking.

Commercial bearing begins in the third or fourth year. The time of leaf plucking and the number of pickings depends on the location of the tea area and the physical conditions within the region. Fundamentally, the nature of the yield depends upon the length of the moist season: if long,--as in Java, Sumatra, British India, and Ceylon--25 or 30 pickings can be made from March to October;[47] if short,--as in China, Japan, and Taiwan--only 3 or 4 pickings are made annually from April through September.[48] The first picking which follows the flush growth during spring rains supplies the best quality teas; those leaves which are picked during mid-season are larger, thicker, and tougher, and are used in making strong teas; the final pickings bring in a lower grade of tea used primarily for local consumption. The yield may be anywhere from 200 to 1000 pounds of leaves per acre, and trees continue to yield for fifty years or more.[49]

In harvesting, the leaves are plucked by hand or with scis-

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47 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 503.

48 Ibid., p. 503.

49 Ibid., p. 503.

sors, being nipped off cleanly without bruising or breaking the stem or stalk. Plucking the leaves is a tedious task and requires considerable skill. The painstaking work is done by skilled men, women, and children. It is improbable that any kind of machine can ever be devised to perform this work.[50] An expert can pick from 25 to 75 pounds of leaves in a day.[51]

In a single picking time five grades of leaves, depending on the age of the leaves on the bush, are obtained: the tips of the branches (the youngest buds) furnish the "golden tips" of commerce; the leaf next in size to the bud is used for "orange pekoe"; the second leaf from the bud, "pekoe"; the third leaf, "pekoe-souchong"; the fourth leaf, "souchong"; and the fifth and largest leaf to be gathered--from one to two inches long--, "congou", being the coarser plucking and so of poorest grade.[52]

Two types of tea are prepared from the leaves: green and black teas. The type of tea depends on the method used in preparation processes which require patient, skilled, cheap labor. The leaves are first exposed to the sun or heated in shallow trays until they become soft and pliable. Then they are rolled, by hand or machine; this curls the leaves and removes some of the sap. Finally, the curled and twisted leaves are completely dried in the sun, over fires, or in a current of hot air--this

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50 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 532.

51 Ibid., p. 503.

52 Ibid., p. 503.

last step known as "firing". This final product is known as green tea; the leaves are dull green with an even texture and quality. To obtain black tea, the more popular type, the rolled leaves are allowed to ferment before the "firing" process. Fermentation consists of covering and keeping warm the rolled leaves, thus causing them to lose their green color and change their flavor. Then the leaves must be "fired" after fermentation.

China produces both green and black tea.[53] Japan primarily produces and exports green tea.[54] The black teas are produced on the modern, scientifically managed plantations of Ceylon and India.[55] The so-called Oolong tea of Taiwan is only partially fermented and is intermediate between black and green tea, with the color of the former and the flavor of the latter.

Scented teas are prepared by drying the leaves with fragrant flowers, and then sifting out the dried leaves. Brick tea is made by steaming for a few minutes the tea dust, leaf remnants, and coarser leaves, especially from the last two pickings, and then pressing them into molds, sometimes with the addition of a little rice paste. Brick tea was formerly exported in large quantities from China to Russia, but the trade with Russia in brick tea has all but disappeared; today it moves by

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53 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 178.

54 Ibid., p. 180.

55 Ibid., p. 184.

pack train overland to central Asia (Tibet).[56]

For more than a century China satisfied all demands for tea in world trade. Today though China produces nearly one-half the world's tea, and India and Ceylon supply about 22 per cent and 13 per cent, respectively, however, India and Ceylon are responsible for 63 per cent of the world's tea exports,[57] followed by the Netherlands Indies with 17 per cent, China with 10 per cent, Japan with 4 per cent, and Taiwan with 2 per cent. Farmers and merchants of China lost the tea market of the world to the commercial plantations, especially those of southern Asia. China's lack of systematic planting, poor methods of cultivation used on numerous scattered small gardens, inefficient methods of preparation of the tea, and failure of sorting establishments to supply large consignments of tea of uniform quality explain her inability to compete with those producing on modern, scientifically-managed plantations.[58] The scientifically-managed plantations have been able to produce tea at lower costs. They are located where a long harvesting season is possible and so provides a more even distribution of labor required in picking and preparing the tea, a factor significant in labor cost. Also, plantation areas on the whole are favorably located with respect to modern transportation facilities.[59]

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56 Op. cit., p. 178.
57 Ibid., p. 177 (fig. 110).
58 Ibid., p. 184.
59 Ibid., p. 184.

The United Kingdom takes more than 38 per cent of the tea imports of the world (in the years prior to World War II). The United States is second with 10 per cent (86,234,659 pounds in 1935),[60] followed by the U. S. S. R. with 6 per cent, Australia with 5 per cent, Canada with 5 per cent, The Netherlands with 4 per cent, and Ireland with 3 per cent.[61] China and Japan before World War II supplied the United States with teas while the United Kingdom was the chief consumer of India and Ceylon teas. Java's surplus went to Europe and Australia.

Cassine. Cassine is a tea-like beverage obtained from two species of holly, Ilex cassine and Ilex vomitoria.[62] These small trees bear small, oval, evergreen leaves. The tree occurs on the sandy soils of the Atlantic and Gulf Coastal Plains of the United States from Virginia to Mexico.[63] The Indians formerly used cassine for beverage purposes; they prepared an infusion of fresh or dried leaves which was known as yaupon or black drink. This was used medicinally as a spring tonic. It was sometimes fermented.

Recently attention has been directed to the beverage as a basis for soft drinks. The leaves and shoots are picked and

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60 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc. 1937, p. 506.

61 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 187 (fig. 110).

62 Op. cit., p. 512.

63 Ibid., p. 512.

dried in the sun on trays or are roasted ovens.[64] Twigs and older leaves are sometimes steamed, dried, and ground. The beverage is prepared by boiling or making an infusion. It is dark-colored, with a very sharp, bitter taste and tea-like odon.

DYES AND PIGMENTS

Osage-Orange. The osage-orange or American fustic (Maclura pomifera) is one of the few native sources of a dyestuff. The tree is a native of the states bordering the Gulf of Mexico, being originally confined to the rich bottom lands of the Arkansas and Red River Valleys.[65] The tree is most abundant at present in the bottomlands of southern Arkansas, Oklahoma, and Texas.[66]

Dyes are obtained from the dark orange inner bark and bright orange-colored sapwood which turns to a deep yellowish brown on exposure. These dyes were used by the American Indians to dye their blankets. More recently the wood has been a source of orange-yellows, gold, tan and khaki dyes, and as a base for greens; the wood yields a tannin as well. Osage-orange is used on leather, wood, paper, and, to a smaller extent, on cotton. If greater demand should rise for it, 40,000 to 50,000 tons of

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64 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 512.

65 George H. Collingwood, Knowing Your Trees, American Forestry Association, 1941, p. 162.

66 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 420.

osage-orange could be readily produced yearly in the states of Texas and Oklahoma.[67]

Sumach (American). This native material is used to a very limited extent as a dyeing material; the leaves, leaf stalks, and smaller twigs are a source of dyes.[68] The American sumachs (Rhus glabra, R. typhina, and R. copallina) are more important, however, as a source of tannins and are found in the Humid Subtropical climatic area of the United States, particularly in Virginia and other southeastern states.[69] American sumach yields a clear orange-colored dye which is used to a limited extent in coloring cloth and fine leather.[70]

FRUITS (EDIBLE)

Feijoa or Pineapple Guava. The feijoa is sometimes called pineapple guava because it is closely related to the guava, and because the fruit has a delicate pineapple flavor. The tree (Feijoa sellowiana) bears fruits which are round, oval, or oblong in shape, one to three inches long, and dull green in color with a little crimson on each cheek. The thin skin encloses a layer of white granular flesh and below this a mass of translucent, jelly-like pulp in which twenty or thirty minute seeds are embedded, so small that they cannot be felt in the mouth.

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67 Op. cit., p. 420.
68 Ibid., p. 419.
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70 Ibid., p. 419.
Ibid., p. 419.

This fruit tree is native to the campos of southern Brazil, Uruguay. Paraguay, and parts of Argentina.[71] It is still grown in those countries. It was introduced into cultivation along the Riviera in southern Europe in 1890 and later into California, Florida, and the Philippines.

The feijoa is subtropical in its requirements of temperature, and demands a fairly abundant rainfall yearly, from 30 to 40 inches, though it does not produce good fruit in the moist tropical regions.[72] The tree is quite resistant to drought and in the dry climate of California it is eminently successful. It has been grown successfully at Santa Barbara, California with no artificial irrigation; yet, if best results are to be obtained, it must be irrigated liberally. Though the tree delights in a dry climate, it at the same time requires freedom from extremely high temperatures.

Sandy loam, rich in humus, is considered to be ideal soil for feijoa.[73] It does not do well on sandy soils rich in lime, such as exist in Florida and Louisiana.

So far propagation has been largely by seed, though this is not the most satisfactory. Layering is used in both California and France, while in the Philippines shield budding on

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71 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 293.

72 Ibid., p. 293.

73 Ibid., p. 293.

bear two or three years after planting. The trees are not very productive in areas into which they are introduced probably because of the absence of birds which in the native haunts transferred the pollen as they flew from blossom to blossom eat the fleshy sweet petals.[74]

In California the fruit ripens from September to December. Fruits drop to the ground when mature. If harvested before maturity, they lack flavor, hence they are allowed to hang until the maximum of flavor is developed. After gathering, the fruit is laid in a cool place to reach the proper condition for eating purposes. Because this fruit can be kept three or four weeks after ripening, it enables them to be shipped to most markets if kept under refrigeration.

So far no satisfactory method of commercial handling of the crop has been developed, because the first problem is to develop a sufficient quantity of fruit, and present indications are that this will be done.

Besides being eaten fresh and stewed, the feijoa is used in preserves, jams, and jellies.

The Fig. See pages 438 to 443.

The Grapefruit. See pages 438 to 448.

The Kumquat. Though not strictly a citrus fruit, the kum-

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[74] Samuel Fraser, American Fruits, Orange Judd Publishing Company, Inc., 1924, p. 670.

quat is popularly so classed. It is the smallest of all those considered in this classification. The kumquats are golden yellow fruits produced in clusters on a small evergreen tree (Citrus fortunella). The fruit is oval, about the size of the last section of a man's thumb. The pulp is somewhat acid, and is eaten raw together with the rind which has a very sweet aromatic taste, or the fruit may be preserved also.

The kumquat is native to China and Japan. It is now distributed in humid subtropical portions of the world, being better adapted to a climate with wet summers than is the orange and lemon. In the United States it is grown in the Gulf States, in California, Florida, and as far north as Augusta, Georgia.[75] In Asia kumquats are found in India, in Japan between 30° and 48° North Latitude,[76] and in eastern China from latitude 20 to 30 degrees in the vicinity of Canton, also on the hills about Hongkong, and on the adjacent parts of the mainland. Recently the kumquat was introduced into Europe in the southern portion of the Mediterranean Subtropical climate about the Mediterranean Sea. In Australian deserts thrives a kumquat possessing considerable drought-resisting ability and bearing edible fruit.[78]

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[75] Op. cit., p. 670.

[76] H. Harold Hume, The Cultivation of Citrus Fruits, The Macmillan Company, 1926, p. 115.

[77] Ibid., p. 115.

[78] Op. cit., p. 672.

The tree requires tropical and subtropical temperatures, preferably where there is a summer rainfall. These conditions are best met by the regions having the Humid Subtropical climate; but the tree will thrive in a Mediterranean Subtropical climate, provided irrigation is possible there. When dormant, the trees have been known to withstand temperatures of 15° F., being more hardy than most citrus fruits.[79] For this reason kumquats are possible north as far as Augusta, Georgia.[80] Light, sandy soils are best suited to the kumquat, though the tree will thrive in other well-drained soils such as are required by the lemon and orange.[81]

In the United States the kumquat is a cultivated orchard fruit, while in China and Japan it grows wild. For orchards shield budding on rough lemon or sweet orange stock is employed. Then the young plants are set out in hedge fashion. The soil requires the use of fertilizers to insure strong tree growth. Liberal or even severe pruning is necessary to induce stronger growth, resulting in an increase in size and quantities of fruit. The mode of gathering the fruit insures a certain amount of pruning for the fruits are clipped from the plants with leaves and twigs attached; but if the crop is light, additional pruning can be given. The fruit is usually shipped in small

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79 Samuel Fraser, American Fruits, Orange Judd Publishing Company, 1924, p. 670.

80 Ibid., p. 670.

81 Ibid., p. 671.

baskets, the bulk of the movement being timed for the holidays.

Kumquat is a comparatively new fruit and few persons are familiar with it. It is regarded as nothing more than a fancy fruit, and in most cases a demand must be created for it. Any market in the United States could be glutted by large shipments, but in a small way the fruit is profitable. Though the fruit may be eaten raw, it is used chiefly in making jellies, marmalades, and various preserves. Candied and preserved kumquats are imported into the United States from China; Japan has furnished us with kumquat marmalade.

The Lemon. See pages 448 to 453.

The Litchi. The Litchi chinensis produces the most important of all the fruits of southern China,[82] and is as important a fruit in China as the peach is in America. The fruits are regarded by the Chinese as the most luscious of their fruits, and in Asia millions of people are familiar with it. The fruits are very distinctive. They are round and are borne in clusters. The outer coat is bright red, hard, leathery, becoming brown and brittle on drying. The pericarp is rough, causing the fruit to look like a nut. A translucent white flesh surrounds the single large seed. When dried, the litchi "nuts"--the flesh--has a raisin-like consistency.

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82 Woon Young Chun, Chinese Economic Trees, Commercial Press, Ltd., Shanghai, 1921, p. 238.

The litchi is a native of the south of China, Cochin-China, Siam, India, Malay Archipelago, and the Philippines,[83] and has been an important fruit in southeastern Asia for over 2000 years. It is now extensively grown in the tropics and has been introduced into some parts of the subtropics. At present this fruit is grown principally in northern India and China.[84] The principal provinces of China in which litchi are grown are Fukien, Kwantung, and Szechwan.[85] In Kwantung province alone the annual crop is said to be 20 million to 30 million pounds, worth between $1,000,000 and $1,500,000.[86] The region around Canton is considered the most favorable part of China for litchi culture.[87] North of Foochow the tree is not successful.

Though not grown so extensively in India as in southern China, there are several districts in which they are produced commercially. The most important are said to be in Bengal, about Muzaffarpur, and at Saharanpur (United Provinces of Agra and Oudh).[88]

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83 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 315.

84 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 315.

85 Ibid., p. 315.

86 Ibid., p. 315.

87 Ibid., p. 315.

88 Ibid., p. 315.

The tree is cultivated on a limited scale in Cochin-China, Madagascar, Brazil, and the West Indies. It does well in Hawaii where fresh litchis sell for 50 to 75 cents a pound.

Litchi is a promising fruit, commercially in southwestern Florida, especially in the Fort Meyers region where there is relative freedom from frost and where the soils are deep and moist. It is doubtful whether commercial litchi culture will become a success in southern California because the dry summer and cool winter weather is unfavorable. Litchis have been grown at Santa Barbara and in the foothill region near Los Angeles (Glendora and Monravia) indicating that litchis may be grown on a small scale in California if planted in sheltered situations and given protection from frost for the first few years.

In general litchi is tropical in its requirements. It requires tropical temperatures--abundant rainfall and freedom frost. It can be grown in subtropical regions, however, where severe frosts are not commonly experienced. Young trees cannot withstand frosts. When mature, the trees will stand several degrees of frost without injury. Although the tree prefers a humid atmosphere with an abundance of rainfall, it does well in a relatively dry subtropical climate where abundant water can be supplied by irrigation.[89] Heavy winds are injurious, especially while the tree is in bloom.

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89 Op. cit., p. 315.

Although the best soil is a deep rich alluvial loam, it does well on light sandy loams if there is an abundance of soil moisture.

Litchi is easily propagated by layering, grafting, or inarching. Little pruning is necessary. Seedling trees normally come into bearing anywhere from three to seven years of age.[90] Under good cultural conditions the tree can be expected to produce a crop every year. Each tree yields 200 to 300 pounds of fruit yearly; crops of 1000 pounds have been reported.[91] Approximately two tons may be expected from an acre of planted trees. Thinning the fruit is done to reduce the number in the cluster and this tends to increase the size of the fruit. The trees are long-lived, and should continue in profitable bearing for a hundred years.

The fruit ripens from May to July in the northern hemisphere. The custom is to break off the twig which bears the fruit, because if individual fruits are gathered they lose their keeping qualities. Fruits may be held two to three weeks without loss of flavor, but soon loses the red color.

Though some fruit is shipped under refrigeration to be sold fresh as dessert, the rest is either dried or preserved in cans for sale in the United States and Great Britain.

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90 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 315.

91 Ibid., p. 323.

The Loquat. See pages 453 to 456.

The Mulberry. See pages 456 to 466.

The Orange. See pages 466 to 475.

The Peach. See pages 475 to 482.

The Persimmon. See pages 482 to 485.

The Tangerine. See page 485 to 486.

GUMS AND RESINS

Hard Resin

Lacquer. Lacquer is a natural varnish that exudes from various Asiatic trees. Enormous quantities of it are used in Oriental countries for ornamental purposes. Rhus verniciflua is the principal source of this hard resin.[92] The tree is a native of China; it has long been cultivated in Japan.[93] Natural lacquers are also obtained in Taiwan.

The trees are carefully cultivated and systematically tapped. A milky liquid which darkens and thickens rapidly on exposure exudes from the incisions made in the tree. The exudation can be kept unchanged, however, for long periods by storing in closed containers. Before use it is filtered. When ap-

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92 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 177.

93 Ibid., p. 177.

plied as a varnish, the thin film rapidly hardens in a moist atmosphere, owing in part to oxidation. Lacquer affords a remarkable protection to articles to which it is applied, being unchanged by acids, alkalies, alcohol, or heat up to 160° F.

Oleoresins

Crude Turpentine. Crude turpentine is a gum (oleoresin) which is obtained almost exclusively for commercial purposes from several species of coniferous trees. It may occur as a viscous, honey-like liquid, or soft and brittle solids. The resinous exudate is secreted and stored in ducts near the cambium layer, and exudes naturally as a soft, sticky substance, often called pitch or crude turpentine. For commercial uses, the crude turpentine is obtained by tapping the trees. On distillation the gum yields the essential oil or spirits of turpentine, and rosin, both of which are exceedingly useful products. These three products--pitch, turpentine, and rosin--came to be known as "naval stores" because of their importance during the days of wooden shipbuilding when these products were required by that industry. Now, though still referred to as "naval stores", their uses are not particularly related to shipbuilding. Thus it can be seen that the "naval stores" industry is one of the oldest of the forest industries. About two-thirds to three-fourths of the world's crude turpentine comes from southeastern United States and most of the remainder from southwestern

France.[94]

The United States is the main producer of turpentine and allied products. The region of production includes the sandy strip of coastal lowland along the Atlantic Coastal and Gulf Coastal Plains, chiefly in the eight coastal states from North Carolina to Texas, inclusive.[95] Ninety per cent of the total production here is from the long-leaf yellow pine (Pinus palustris); slash pine or Cuban pine (Pinus heterophylla) is also tapped in the same vicinity.[96]

In the early days New England was an important center; later the industry migrated to the forests of resinous pine in the Carolinas where production rose and fell, then moved to the Gulf Coast states. This migration of the turpentine industry was the result of destructive tapping methods, which allowed a tree life for only five years after tapping commenced. However, new methods have been introduced and the use of second growth forests which have reached the productive stage indicates that the permanence of the industry in southeastern United States is assured. In 1937 Georgia produced about 40 per cent

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94 C. Langdon White and George T. Renner, Geography: An Introduction to Human Ecology, D. Appleton-Century Company, Inc., 1936, p. 298.

95 xNelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 167.

96 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 181.

of the nation's output of turpentine and rosin;[97] Florida was in second place, and Alabana, third.[98] In recent years the average annual yield of turpentine and rosin in the United States has been about 32 million gallons of turpentine and more than 1 million pounds of rosin.[99]

Europe is the second greatest producer of naval stores: total production there is exceedingly small in comparison to that of the United States. Greatest European production is from southwestern France, the industry being centralized in Landes,[100] a flat, sandy, triangular coastal plain between the Adour and the Gironde Rivers, and the Bay of Biscay:[101] this area lies between Bordeaux and the Spanish frontier, an area of about 2,000,000 acres.[102] Here the forests are of almost pure maritime pine (Pinus maritima),[103] trees which are smaller than

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97 J. Russell Smith and M. Ogden Phillips, North America, Harcourt, Brace and Company, 1940, p. 328.

98 Ray H. Whitbeck and Vernon C. Finch, Economic Geography: An Economic Survey, McGraw-Hill Book Company, Inc., 1941, p. 132.

99 Ibid., p. 131.

100 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 67.

101 William O. Blanchard, The Landes: Reclaimed Waste Lands of France, Economic Geography, II (1926), p. 250.

102 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 441.

103 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 184.

the long-leaf yellow pines of our South. The industry in Landes is highly developed. One hundred and fifty years ago this region of France was a sandy wasteland, unproductive, unhealthful, and almost unpopulated. In order to protect other lands from the moving sand dunes bordering the coast, the French planted resinous pine trees on the dunes to hold the sand in place, and drained and planted the rest of the area. Now the Landes is a vast pine forest where naval stores help support a million and a half people.[104] The products are of the highest quality and are preferred to those produced in the United States.

Spain is the third largest producer of naval stores; here four species of pine are tapped--Pinus pinaster, P. halapensis, P. nigra, and P. pinea.[105] Most of the forests are under government control. In Portugal the industry is also becoming prominent, and vast areas are as yet untouched.[106] P. pinaster and P. pinea are the sources of crude turpentine in Portugal. Greece is also increasing in importance among the producers of naval stores, utilizing P. halapensis.[107] Poland, Russia, and

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104 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 68.

105 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 184.

106 Ibid., p. 184.

107 Ibid., p. 185.

Germany obtain inferior grades of rosin and turpentine from P. sylvestris.

The turpentine industry is now being developed in many parts of Asia, particularly Indo-China, the Dutch East Indies, and India.[108] In India several species of pine are available, and also the only non-coniferous tree that is a source of turpentine and rosin. This is the Indian frankincense (Boswella serrata). The great distances and lack of transportation facilities have handicapped the industry in India, but in spite of all obstacles it continues to expand. The British government has fostered the industry, for India is practically the only part of the empire where naval stores can be produced.[109]

The resinous pines used most largely for "turpentining" thrive best in the Humid Subtropical (for southeastern United States) and warmer parts of the Marine West-Coast (for southwestern France) climates. These resinous pines do best on sandy portions of the coastal plains where the soil is well-drained.

The first woods operation in the turpentine industry is known as "boxing"; this is carried on in winter and consists of cutting a cavity near the base of the tree, three to four inches wide, six or seven inches deep, and one foot long. From one to four of these boxes are cut on each tree. Next comes "cornering", which enables the resin to flow into the box more freely.

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108 Op. cit., p. 185.

109 Ibid., p. 185.

Chipping, the reexposing of the cambium, has to be performed every week; otherwise, the oxidation and crystallization of the resin would clog the old ducts. Every three weeks the resin is removed from the boxes and carried to the distillery. At the end of each season the resin that has adhered to the face of the cut and never reached the box is scraped off.

The recent introduction of a cup and gutter system of tapping the trees is productive of a greater yield and is much less wasteful; there is also much less injury to the tree. The "boxing" method destroys the tree in about five years, while the cup and gutter system which is used extensively in Landes allows tapping to continue for as long as forty years.

The process of distilling the crude turpentine lasts for two or three hours. Oil of turpentine is the product received as a result of distillation, while the residue in the stills, when cooled and completely hardened, is the rosin.

The oil of turpentine has many uses: it is used principally in a variety of industrial products including paint and varnishes, printing of cloth, as a solvent for rubber and gutta-percha, in medicine, and in the manufacture of many chemicals.

Rosin is even more important in industry. It is used in the manufacture of soap, varnishes, paints, oilcloth, linoleum, sealing wax, printer's ink, roofing, floor coverings, and various chemicals. It serves as the chief sizing material for paper, and constitutes the brewer's pitch used for beer barrels.

OILS (FIXED AND ESSENTIAL)

Fixed Oils

Tung Oil. This oil, as the name indicates, is a derivative of the seeds of the tung nut, the nut-like fruits of the Aleurites fordii and Aleurites montana, or tung tree.[110] The term China wood-oil is used interchangeably because of the oil's widespread use as an ingredient for oiling wooden boats in China as a waterproofing preservative.

Tung trees are native to the humid subtropical portions of China--the Yangtze Valley and adjacent areas.[111] China still leads the world in tung oil production. Tung trees are extensively cultivated in the Chinese provinces of Szechuan, Yunnan, Hupeh, Hunan, Chekiang, Kwangsi, Anhwei, Kweichow, Honan, and Fukien.[112] Because the climatic conditions in Szechuan are particularly favorable, the tung tree has been most prolific in that province.[113]

The tree has been introduced into the humid subtropical portions of southeastern United States. Production has been fostered in the Gulf States in a belt roughly extending 100 miles inland, crossing parts of Texas, Louisiana, Mississippi,

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110 Commodity Year Book, Commidity Research Bureau, Inc., 1941, p. 557.

111 Ibid., p. 557.

112 Woon Young Chun, Chinese Economic Trees, Commercial Press, Ltd., 1921, p. 208.

113 Op. cit., p. 557.

Alabama, Georgia, and Florida.[114] The areas of best production are in Florida and Mississippi.[115] The largest acreage is now in Mississippi's Pearl River Valley;[116] the highest returns per acre are from groves near Gainesville, Florida.[117] Experimentation in tung production is being carried on in Argentina.

Areas of tung oil production are restricted to regions having the Humid Subtropical climate. The tung tree has a natural affinity for a mild, humid climate;[118] it demands considerable rainfall--30 inches or better.[119] Being deciduous the tree needs a cool period of dormancy, and so winter cold as it occurs in this climatic type is not harmful. It is when the tree is in bloom that the greatest danger from frost occurs. Frosts at that time of year may result in complete crop failures--as they did in the United States in 1932, 1933, and 1935. This danger can be partially overcome by careful selection of sites for the location of groves, selecting only those where there is good air drainage. Cold air accumulating in pockets in gullies are dangerous to the blooming trees. Such accumu-

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114 Roy L. Pepperburg, Tung Trees--The South's New Cash Crop, Reader's Digest, 1939, p. 102.

115 Ibid., p. 102.

116 Ibid., p. 102.

117 Ibid., p. 102.

118 Commodity Year Book, Commodity Research Bureau, Inc., 1941, p. 557.

119 George F. Deassy, Tung Oil Production and Trade, Economic Geography, XVI (1940), p. 268.

lations of cold air may be circulated by a low-flying plane in order to prevent danger from spring frosts, but this is expensive and reduces the possible profit.

The tung tree prefers a slightly acid, rolling ground[120] that drains easily. Hillsides are preferable because they provide not only the necessary soil drainage, but also the good air drainage. Rocky hillsides and other waste lands unsuited to the growing of foodstuffs, especially in China, could be more generally planted to this tree to good advantage.

In normal peace time China produced over 100,000 tons of tung oil.[121] Despite this enormous annual output, the basis of the native industry is supplementary cultivation. Large tung tree plantations or groves are not common in China; small plantations may be found in the Yangtze Valley and in the vicinity of Hankow.[122] In China the trees are not planted as a primary crop. Tung nuts have been an incidental item, after other necessary staples and produce have been planted and harvested.[123] Therefore, they are to be found planted sparingly on hillsides which are adjacent to farmlands. Individual farmers sell their

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120 Roy L. Pepperburg, Tung Trees--The South's New Cash Crop, Reader's Digest, 1939, p. 102.

121 Commodity Year Book, Commodity Research Bureau, Inc., 1941, p. 560.

122 Woon Young Chun, Chinese Economic Trees, Commercial Press, Ltd., 1921, p. 208.

123 Op. cit., p. 557.

harvested nuts to village buyers who purchase the nuts for extraction of the oil in their mills.[124] Thus, in China tung nut production serves as a supplementary income to the small farmers. The Chinese government has, however, in recent years endeavored to encourage new plantings and cultivation because of the commercial nature of this nut crop.[125]

The tung tree is one of our South's many new crops. Large scale plantations are favored in the United States. Small groves of 100 acres have commercial possibilities for the small grower. There is every reason to think it will succeed despite the damage in this region from unexpected frost.

Tung trees are propagated from seed in seed beds, and are ready for transplanting in the nurseries or directly into the field when they attain a height of eight or ten inches. The tree begins to produce fruit, or nuts, at the age of three years, and in their fourth or fifth years production becomes commercially important and increases up to the twentieth or thirtieth years;[126] the tree continues to bear effectively for fifty years or more. The tree bears brown, hard, woody nuts which fall to the ground in October or November, and are gathered and sent to mills where the oil is pressed from the seeds. An acre of 116 trees which are five years old will produce about

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124 Op. cit., p. 560.

125 Ibid., p. 557.

126 J. Russell Smith and M. Ogden Phillips, North America, Harcourt, Brace and Company, 1940, p. 355.

116 bushels of nuts, yielding 5.6 pounds of oil per tree;[127] an acre of eight year old trees will yield enough fruit to make 1000 to 1500 pounds of tung oil.[128]

Since 1931 records reveal that production of tung oil in the United States has been increasing. The acreage in tung trees has in that time grown, from about 140 acres around Gainesville, Florida, in 1923 to 160,000 acres in 1938, which were scattered from Florida to Texas.[129] In 1931 about 125,000 pounds of tung oil were produced; in 1938, 3 million pounds;[130] a peak was reached in 1940 when 5 million pounds were produced. However, the total oil produced in the United States since 1931 has been less than 1 per cent of the total amount of tung oil consumed in this country. In 1935 the United States imported 120,058,817 pounds of tung oil from China.[131] Hence, the American industry cannot depend upon domestic production to supply them with any appreciable amount of tung oil for many years to come.

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127 J. Russell Smith and M. Ogden Phillips, North America, Harcourt, Brace and Company, 1940, p. 355.

128 J. Russell Smith, Men and Resources, Harcourt, Brace and Company, 1937, p. 222.

129 Op. cit., p. 355.

130 Commodity Year Book, Commodity Research Bureau, Inc., 1941, p. 562.

131 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 227.

The uses of tung oil are many. In China it is used as a waterproofing material--for wood, cloth, silk, and paper,-- as an illuminant, in the manufacture of Chinese ink, in medicine, and in high-gloss varnishes. Because tung oil is the most rapid of the drying oils, it is more satisfactory than linseed oil in the varnish industry and has almost revolutionized that industry by producing a quick-drying varnish. It is also used for paints, linoleum, leather dressings, and waterproofing insulation for electrical apparatus.

Essential Oils

Camphor Oil. Camphor is the most important of the essential oils used in industry, and it is obtained chiefly from wild trees. The distillation of the wood, twigs, and leaves of the true camphor tree (Cinnamomum camphora)[132] yields the camphor oil and the crystals known commercially as camphor gum.

The true camphor tree is a native of Taiwan, China, and Japan, but it has been widely introduced and cultivated in many of the tropical and subtropical regions elsewhere, chiefly as an ornamental plant. This tree grows wild in the forests on the mountain slopes of Japan proper, Taiwan, and southeastern China.[133] The greater part (about 75 per cent) of the world's

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132 Woon Young Chun, Chinese Economic Trees, Commercial Press, Ltd., 1921, p. 151.

133 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 65.

supply of pure camphor is produced by Taiwan alone.[134] Thus, the Japanese who control this island have a virtual monopoly of the camphor industry. The industry is so valuable in Taiwan and Japan proper that the Japanese government regulates it and owns much of the forests. In China the provinces of Kiangsi, Fukien, and Kwangtung are involved in some camphor production. Because of the importance of the camphor oil in the United States--a country consuming approximately 3000 tons a year--the growing of camphor trees has been experimented with in Florida, Texas, and California.[135] Today camphor is a crop of increasing promise, especially in Florida where nearly 10,000 acres are now devoted to this tree.[136] Attempts have also been made to start camphor production in Ceylon.

Environmental requirements restrict the production of camphor trees to those regions of Humid Subtropical climate which have well-drained soil, heavy annual precipitation, and tropical to subtropical temperatures.[137] The greatest problem of the camphor industry is the difficulty and expense involved in transporting the oil and crystals from the mountainous districts to the ports for shipment to the world markets; but because

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134 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 206.

135 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 65.

136 Op. cit., p. 207.

137 Op. cit., p. 65.

these products are so valuable, it pays to carry on the industry despite the expense connected with the difficulties of transportation.[138] One tree alone may yield more than $5000 worth of camphor.[139]

Most of the present camphor industry is dependent on the trees of the wild forest for the bulk of its resin.[140] In these forests the camphor trees grow in mixed stands. In Japan only trees fifty years of age or older may be felled;[141] then the wood is chopped into small pieces or ground into a powder, and finally the camphor is distilled from it over boiling water for about three hours in small native stills which are located throughout the forests where the camphor is collected. The crude camphor crystallizes on the walls of the still; this is removed and must be purified before it is ready for market.

Japan has, however, maintained the system of planting large areas in Taiwan with cultivated trees. The discovery that the leaves and twigs as well as the wood may be distilled with good results has led to the cultivation of these seedling trees which may be pruned back several times a year instead of cutting down the entire tree as was formerly done. Cultivated

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138 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 65.

139 Ibid., p. 63.

140 Ibid., p. 63.

141 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 207.

camphor trees are propagated by seeds in nurseries and are later transplanted. As transplanting is extremely difficult and rarely attended with success, it is more common to sow the four or five seeds per hole directly in the forest under the shelter of standing trees which afford the requisite shade for the growth of seedlings.[142] For the first few years some care must be given them--thinning and weeding. In establishing a new plantation, however, seedlings transplanted from the seed-beds should be transplanted into pots where they are allowed to remain until ready to be set out into the permanent plantation.

The modern practice is to utilize only the twigs and leaves, other than the old wood. Therefore, clippings can be made from the seedling trees when they are three or four years old, and three or four times a year thereafter.[143]

The United States in 1935 imported about 4,000,000 pounds of camphor (both crude and refined) and camphor oil for various uses.[144] The principal commercial use of camphor is in the manufacture of celluloid and various nitrocellulose compounds--smokeless powder and high explosives.[145] Camphor also has wide range in medicinal uses, both internally and externally. It is in addition used in perfumery, plastics, movie films, and in

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142 Woon Young Chun, Chinese Economic Trees, Commercial Press, Ltd., 1921, p. 154.

143 Albert F.Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 208.

144 Ibid., p. 209.

145 Ibid., p. 209.

making moth balls.

The modern camphor industry is faced with competition from a synthetic product. A camphor-like substance prepared from oil of turpentine in scientific laboratories at low cost threatens to become a competitor on the world markets.

Oil of Petit-grain. The source of oil of petit-grain, a product in demand in this country as a base for perfumes and flavoring extracts, is the wild bitter-orange (Citrus aurantium) and the wild sweet-orange (Citrus sinensis) trees. The former is a native of southeastern Asia; there is every probability that the eastern region of India was the original home of this tree,[146] and from there it spread westward slowly--to Mesopotamia, Palestine, Sicily, and Spain.[147] The Spaniards carried it to Florida and South American countries during their explorations of the New World and here the bitter-orange ran wild. Dense thickets of this tree now exist in the humid subtropical forests of Florida and Paraguay.[148] The latter tree is a native of southern China and Cochin-China, and was introduced into Europe by the Portuguese from southern China at an early date. The Portuguese carried the sweet-orange to Brazil

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146 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 185.

147 J. Eliot Coit, Citrus Fruits, The Macmillan Company, 1915, p. 41.

148 Ibid., p. 41.

where it ran wild, and from Brazil it spread southward to eastern Paraguay, part of Uruguay, and northern Argentina where large areas are now covered with a natural growth of wild sweet-orange trees.[149]

The oil of petit-grain is obtained by distillation from the young and tender leaves and shoots of both the bitter and sweet-orange.[150] Formerly the oil was produced principally in southern France, but toward the end of the 1870's French colonists began the distillation in Paraguay.[151] Today petit-grain is the source of a considerable wealth from the forests of eastern Paraguay where the wild bitter-orange tree occurs in dense thickets, serving as the source of this oil.[152] Here the oil is distilled by the natives from the leaves of this tree.

The chief requirements of the industry in Paraguay include a stream of clear water, a primitive palm-thatched shelter for a simple furnace fed by wood from the vicinity, and a large vat from which leads a pipe coiled in a cooling chamber where the condensed vapor gathers. However, poor methods of production and restricted demands limit its importance.[153] The principal

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149 Op. cit., p. 42.

150 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 201.

151 James B. McNair, Citrus Products (Part I), Field Museum of Natural History, 1926, p. 195.

152 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 290.

153 Ibid., p. 290.

place of distillation of oil of petit-grain is the little town of Yuguaron; the principal market is Asuncion.[154] From this market the United States imported approximately 56,000 pounds of petit-grain oil in 1935 for the manufacture of flavoring extracts and perfumes.[155]

TANNING MATERIALS

Quebracho. This is the world's greatest single source of tannin today. The extract is obtained from the heartwood of a medium-sized tree which resembles the live oak of our South. However, the tree most extensively exploited for tannin extract is the Quebracho colorado (Schinopsis lorentzii).[156]

The native habitat of the quebracho tree is along the water courses and plains of central South America, embracing southern Brazil, southeastern Bolivia, Paraguay, Uruguay, and northern Argentina,--a district of about 300,000 square miles commonly referred to as the Chaco.[157] More definitely, the region of commercial exploitation extends from the northern part of the Santa Fé province in northern and northwestern portions

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154 James B. McNair, Citrus Products (Part I), Field Museum of Natural History, 1926, p. 195.

155 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 209.

156 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 287.

157 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 87.

of Argentina, through the Argentine Chaco, the province of Santiago del Estero and the Formoso Territory, into Paraguay and Bolivia, with the chief exploitation being confined to a narrow belt on the west side of the Paraná-Paraguay River.[158] The belt stretches for a distance of 750 miles along the Paraná-Paraguay line, but it reaches west from that line over a width that varies greatly--in some places not more than 25 miles, in others up to 200 miles.[159] The best forests both for density and quality of trees were originally in the Santa Fé province, beginning about 10 miles back from the Paraná, but with the heavy cutting that has taken place for a number of years past, this stretch is becoming less important and first place is being taken by the Argentine Chaco.[160] Away from the river the number, size, and value of the trees decrease as do also the number of forest belts.

Natural conditions restrict the areal distribution of the quebracho to the portions of South America having the Humid Subtropical characteristics of climate. Therefore, these trees grow best where the temperature rarely exceeds 105° F. and seldom drops below 32° F. (subtropical temperatures);[161] where the

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158 Edward W. Shanahan, South America: An Economic and Regional Geography, E. P. Dutton and Company, 1927, p. 196.

159 Ibid., p. 196.

160 Ibid., p. 196.

161 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 287.

latitudes are warmer the quality of the tree deteriorates. The tree avoids extremes of wet and dry weather. Its sensitiveness to moisture causes it to be absent where conditions tend to swampiness. Vast stretches of level lands which drain with sufficient rapidity to do away with long inundation and slowly enough to furnish sufficient moisture for trees, support excellent stands of trees.[162] They are rarely found on elevations which are 50 feet above the surrounding lowland; it avoids both slightly elevated tracts which get very dry during winter, and depressions occupied by permanent swamps--so in Paraguay half the trees are defective.[163] An abundance of efficient labor and cheap water transportation are also necessary for the production of a marketable product.[164] Fortunately the quebracho grows near the navigable Paraguay River; this affords cheap transportation for the logs and extract to the ocean ports.

The production of quebracho has more the character of a lumbering industry than of a gathering industry, and is carried on for the most part by corporations of extract companies who own much of the vast timber holdings, or by small private companies.[165] The industries of the interior belong to a number of small capitalists who purchase the logs in small quantities

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162 Op. cit., p. 287.
163 Ibid., p. 287.
164 Ibid., p. 288.
165 Ibid., p. 287.

from forest workers. Quebracho trees are felled; the bark, branches, and sapwood are stripped; the rest is bucked into logs of from four to sixteen inches in length. Only the heartwood is used. Then the logs are hauled by oxen from the forest to the nearest railroad, river, or factory. Formerly, because of the lack of extracting facilities, the logs were hauled out to centers on the lower Paraná and La Plata Estuary whence they were exported as logs to Europe or North America for extraction. At present, instead of shipping the logs, the combined cutting and extraction in the forest region is the method used. The logs are chipped and cooked with steam in extractors until the liquor is very concentrated, with a tannin content of 40 to 60 per cent. This method necessitates seeking out areas heavily forested with trees of good quality in order to make it profitable to keep factories working in the same place for as long as possible. Now that the more accessible forests near the great river highways have been cut, the economic advantage is with the extract factories which have a much wider choice of location in the interior. Such factories are much less dependent upon nearby means of transportation than when located outside the quebracho forests.

The quebracho industry has many handicaps and problems: poor land transportation, especially in wet weather when the roads become almost bottomless channels of mud in a short time; floods during wet weather and droughts at other times of year

both put a stop to work in the forests; inefficient labor; insects, especially mosquitoes and sand fleas; malaria; forest fires.[166]

The great value of quebracho lies in the fact that it has an unusually high tannin content, being twice as much as that of hemlock which is produced in northern countries. This explains why a region so far from the tanning centers has such a large industry. Argentina produces most of the quebracho logs and extract for export; Paraguay which produces much less than Argentina furnishes quebracho products for export, also.[167] Most of the extract and logs from these countries go to Europe, but one-third the United States' supply of tannin also comes from these countries.[168]

Quebracho is used in tanning all kinds of leather, either alone or in combination with other tanning materials.

Sumach (American). The Humid Subtropical climate of the northern hemisphere has three trees which are the source of tannin; the native American sumach, namely Rhus glabra, R. typhina, and R. copallina.[169] In the southeastern states of the

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166 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 288.

167 Ibid., p. 289.

168 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 66.

169 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 139.

United States, particularly in Virginia,[170] the dried leaves of these three sumachs furnish the tannin. The leaves are picked in the fall just before they turn red as the tannin content is dissipated from the leaves as they turn color in the fall. The leaves are then dried and ground into a powder in which form they are shipped to the tanneries. The tannin content of sumach leaves when dried is from 10 to 25 per cent.[171]

NUTS (EDIBLE)

The Pecan. The pecan is a typical American nut, both as to use and production. The pecan tree (Carya pecan)[172] is a native of North America, ranging from the central Mississippi basin into Mexico, being found especially along the streams and on river-bottom lands.[173]

Formerly the pecans were obtained from wild trees, but they have increased in popularity so that the trees are now extensively cultivated in the Southern states where they are commercially important. The bulk of these nuts is being furnished largely from native improved trees[174] and planted orchards in

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170 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 79.

171 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 139.

172 George H. Collingwood, Knowing Your Trees, American Forestry Association, 1941, p. 104.

173 Ibid., p. 105.

174 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 293.

the San Antonio Valley of Texas, the Red River Valley in Oklahoma, and also in Louisiana, Mississippi, Florida, Alabama, and Georgia.[175] Texas, however, leads all states in pecan production. With the introduction of new varieties the area of commercial production has been extended northward into Virginia, Indiana, and into the upper Mississippi Valley, as far as southern Iowa. Small plantings in the valleys of central and northern California are proving to be more profitable than any other nut there.

The climatic requirements of the pecan trees are best met by the Humid Subtropical climatic portion of the United States. The tree requires a comparatively long growing season; so it is not commercially productive in the more northern regions of the United States or at high altitudes within the Southern states. The northern limit of production is 40° North Latitude,[176] involving the southern edge of the climatic belt classified as Humid Continental--Long Summer Phase. Toward the northern margin of production the trees must be grown on uplands for on the lowlands there is danger of late spring frosts. Southern varieties require 270 to 290 days to mature and so are limited to the belt south of 34° North Latitude; northern varieties mature in 180 to 200 days and grow between the 34th and 40th parallels

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175 J. Russell Smith and M. Ogden Phillips, North America, Harcourt, Brace and Company, 1940, p. 313.

176 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1931, p. 296.

north.[177] Being hardier than citrus fruits it is well-suited for fitting into the gap between regions of citrus fruit and middle latitude tree fruits.

Pecans thrive best in deep, porous (but not too light) alluvial soil that is well-supplied with moisture throughout the year and, in addition, is properly drained.[178] Therefore, cleared forest lands, if properly drained, are good for pecan culture. An occasional overflow of the land does not seem to harm the pecan tree as long as the soil is not permanently waterlogged. Alkaline soils are to be avoided because they injure the trees.

Pecan culture at present is concerned with improvement of native trees to bring them into more profitable bearing--by clearing a wild grove or forest of underbrush, followed by thinning the forest, and then budding the shoots arising from the "dehorned" limbs of the wild trees[179]--and planting of pecan orchards. Formerly pecan orchards were limited to seed plantings, but poor results led to budding and grafting by successful propagators who sell them for orchard planting. At present a large proportion of the crop and all the better varieties and higher grades come from such planted orchards or improved native trees. East of the Mississippi orchards of pecan trees

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177 Op. cit., p. 296.
178 Ibid., p. 295.
179 Ibid., p. 294.

are planted; west of the Mississippi bushy meadow pastures full of young wild pecan trees are being grafted and budded to good varieties.[180]

The pecan trees bear their first fruit in about five years after planting.[181] The period of best yields is from the eighth to twelfth years. Maximum bearing is reached by the twentieth year. The pecan tree is biennial in its bearing habits.[182]

A mature grove or orchard produces as much as a ton of nuts per acre in years of good yield. This averages from 25 to 100 pounds per mature tree. Some exceptional trees have recorded yields of from 100 to 1000 pounds of nuts.

The pecan crop is harvested by gathering the nuts from the ground after they have dropped naturally from the tree, or by knocking the nuts off the tree before they shed or before the hulls become dry and tight.[183] Pecans should not be allowed to lie on the ground too long, for they may become discolored; therefore, picking usually occurs several times during the harvest season which begins October first and lasts until April.[184] The husks that adhere to the nuts are either removed in the or-

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180 J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p. 212.

181 Ibid., p. 210.

182 Ibid., p. 206.

183 Thomas J. Talbert and Andrew F. Murneek, Fruit Crops, Lea and Febiger, 1931, p. 302.

184 Op. cit., p. 258.

chard by hand, or else taken off by a huller. Preparation for marketing consists mainly of drying or curing the nuts either in the sun or in special sheds or dryers, with or without artificial heat. In addition, the pecans are sometimes polished and occasionally dyed to enhance their beauty, when an attractive market product is desired.[185] Finally, the pecans are graded according to size, appearance, and quality.[186] A large amount of pecans are sold at present through cooperative organizations or local packing associations. Factories are often located near the supply and here the nuts are cracked and the meats picked out and prepared for shipment. Paper-shelled varieties with a thin shell that can be broken with the fingers have been developed recently.

The United States absorbs most of the pecan crop. They are valued in this country because they are highly nutritious; pecans have a higher fat content than any other vegetable product, over 70 per cent.

CHAPTER XII

TREE CROPS OF THE MEDITERRANEAN SUBTROPICAL CLIMATE

Regions under the influence of the Mediterranean Subtropical climate are rich in the number and variety of economically important tree crops which they produce and for which they find a ready market in other climatic regions. Those found within this climate are mainly of two types: the dry land type--those which are native to this climatic regime and so are naturally adapted to the prevailing summer droughts of the environment; and the intensive irrigated type--those moisture-loving crops which have been introduced here from humid regions, being more profitably grown here under irrigation because of their high returns per acre.

Tree crops of the former type provide the world with a medicinal product, fiber, resins, essential oils, tanning materials, a tree legume, nuts, and cork; the latter, with a wide variety of fruits and nuts, flavoring materials, and an edible fixed oil from olives.

DRUG AND MEDICINAL PRODUCT

Eucalyptus Oil. The scythe-shaped leaves of the eucalyptus tree (Eucalyptus globulus), popularly called the blue gum, contain an essential oil, importantly medicinally. The tree is a native of the savanna forests of northern Australia; it was

introduced into various dry and warm regions of the world about 1850. It is now extensively cultivated in California, where it has been found so profitable that good agricultural land has been planted with it; another thing in its favor here is that the tree is phenomenal in its growth to great size with great speed.[1] Other regions where it is cultivated include the Mediterranean region, southwestern Australia, and parts of Florida and Arizona.

Plantations of eucalyptus thrive well only in climates which are permanently above the frost line. These trees are well adapted to meet the prevailing climatic conditions in the regions of the Mediterranean type of climate; they have the ability to withstand long periods of drought. They have extensive root systems which make it possible to obtain the much needed water supply during the hot, dry summer months. Nature has also endowed the tree with leaves which are leathery in texture, which hang obliquely on their stalks, and which are able to reduce transpiration.[2] The tree can survive temperatures as low as 20° F.

The oil--colorless or pale yellow, spicy, and pungent--is obtained from the dried leaves of Eucalyptus globulus by dis-

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1 J. Russell Smith, Commerce and Industry, Henry Holt and Company, 1935, p. 247.

2 C. Langdon White and George T. Renner, Geography: An Introduction to Human Ecology, D. Appleton-Century Company, Inc., 1936, p. 98.

tillation. In medicine the oil of eucalyptus is used chiefly in the treatment of nose and throat disorders, malaria, and other fevers. It is a very agreeable and efficient drug to add to antiseptic mouth washes because of its antiseptic and stimulating properties.

FIBER

Crin Vegetal. The one fiber produced in the Mediterranean Subtropical climate is obtained from a small palm, Chamoerops humilis, native of Algeria and cultivated in southern Europe.[3]

The leaves of the palm are shredded and the strands twisted into a coarse yarn, making, when picked open, an elastic material somewhat like curled hair.

FRUITS

The Avocado. See pages 112 to 117.

The Apricot. The apricot is a peach-like fruit of the common apricot tree (Prunus armeniaca). The fruit is velvety when young, and has a yellow-orange flesh having a delicate flavor. Unlike the peach the stone is smooth and flattened.

The apricot tree is said to be native to Armenia and China, although some authorities believe it was introduced into Armenia from China, 2000 to 3000 B. C.[4]

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[3] Liberty H. Bailey, Cyclopedia of American Agriculture Vol. II, The Macmillan Company, 1907, p. 292.

[4] Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 227.

Like the peach the apricot, typically a Mediterranean fruit, is limited to other warm parts of the world, especially those having the Mediterranean Subtropical climate. The Levant is the most important commercial area of apricot production of the Old World. Warmer parts of the countries of Southern Europe, Asia Minor, China, Japan, Caucasia, and Syria all produce apricots. South Africa produces apricots in surplus for export. Parts of India and Persia have some apricot plantings.

In the New World the United States is an important producer, a total of 191,000 short tons being produced in 1935.[5] Here it is an intensive orchard industry, while in the Old World it is less intensive and more extensive. California[6] furnishes 90 to 95 per cent of the commercial crop of this country. The fruit is grown in every county except six, and these are in the high Sierras.[7] Early fruit for eastern shipment is grown, principally in the Imperial Valley; later supplies are those from Sacramento, San Joaquin, and Santa Clara Valleys. Fruit for canning is produced principally in the coastal valleys and the San Francisco Bay region, while the crop in the San Joaquin, Sacramento, and interior valleys is dried. The heaviest plantings are in the Santa Clara Valley, the Aromas section of Mon-

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5 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 413.

6 Samuel Fraser, American Fruits, Orange Judd Publishing Company, Inc., 1924, p. 397.

7 Ibid., p. 398.

terey County, and in the so-called "foothills" surrounding the Pajaro Valley in the Santa Cruz County.[8] In southern California, Riverside and Los Angeles Counties lead. Commercial plantings on a small scale exist in protected localities in Oregon, Washington, Idaho, Utah, Colorado, Arizona, New Mexico, Kansas, and New York.[9]

Frost is the chief limiting factor in the production of apricots.[10] Freedom from late spring frosts and freezes is necessary. These trees bloom about a week earlier than peaches and fruit buds and flowers may be injured by such occurrence of frost. Therefore, profitable apricot culture is confined to the milder climate of the subtropics because of the frost hazard. Northern and western exposures are best for apricot orchards because the opening of buds here will be retarded, and danger of frost damage can be more frequently delayed. Orchard heaters are used where frost danger is greatest.

The hot dry summer which is typical of the Mediterranean type of climate is ideal for apricots because rains during the summer have a tendency to encourage brown rot which is a serious menace when the fruit is ripening.[11] Irrigation is necessary only where winter rains do not penetrate the soil to a

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8 Op. cit., p. 398.

9 Ibid., p. 397.

10 Ibid., p. 398.

11 Ibid., p. 398.

depth of five or six feet.

Apricots grow best on deep, sandy loam and gravelly soils which are supplied with adequate amount of moisture, but will not thrive on wet land.

Generally apricots are propagated on apricot, peach, or plum stock. Soon as the orchard is planted, the whole tree is whitewashed to protect it from sunburn which is sometimes troublesome. During the winter of the second season pruning is done to secure shape; and in the following years, so that the sun can reach all parts of the tree. In some cases after fruiting begins, severe thinning of fruits is carried out to produce larger fruits of good quality in preference to quantity.

Although apricots appear on the trees in three years, good yields are more often first obtained in the fourth to sixth years.[12] These trees reach maturity in twelve to twenty years. One disadvantage of the apricot is its biennial character of fruiting only in alternate years.[13] The tree yields for forty or more years.[14] The average yield per acre of fresh fruits varies from three tons to five tons, which if dried gives anywhere from three-fourths to one and one-fourth tons.[15]

The use to which the fruit is put influences the time of

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[12] Samuel Fraser, American Fruits, Orange Judd Publishing Company, 1924, p. 400.

[13] Ibid., p. 400.

[14] Ibid., p. 401.

[15] Ibid., p. 407.

harvest.[16] For shipment in the United States to the eastern markets to be sold fresh, both color and size are considered. They must not be picked too green, for it would not be of good quality. Ripened fruits must be gathered carefully by hand, and the stems must be left attached to the fruit. Three to five pickings are needed. For canning, ripe firm fruit of uniform size is needed and they must be yellow. For drying, hand picked fruit is desired, since those shaken or knocked from the trees give bruised fruit and that does not make a first class dried product; these should be riper than those for canning or to be sold fresh.[17]

In drying the fruits are slit, the pits removed, and the halves are placed outside up on trays which are then exposed to sulphur fumes for three hours in a bleach house.[18] Finally the fruit is sun-dried for ten to twenty days. Many gas dehydrators have been installed in the Santa Clara Valley. The natural gas will dry apricots in from fourteen to thirty hours. Three pounds of fresh apricots give three-fourths pound of dried fruits.

The United States receives most of its apricots--canned, dried, or fresh--from areas of production within the country, and some from the Mediterranean region of Europe. South Africa

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16 Op. cit., p. 405.
17 Ibid., p. 406.
18 Ibid., p. 406.

sends its surplus supplies to England.

Apricots are used as table fruit in regions where they are grown. They are also dried, canned, candied, and made into a paste. A substitute for almond oil is expressed from the seed.

The Cherimoya. The cherimoya is one of the important subtropical fruits, being regarded both by the natives and by Europeans as one of the finest. The cherimoya is essentially a dessert fruit.

The fruit of the cherimoya (Annona cherimolia) are globular or conical, and from four to ten inches long. They weigh from three to five pounds each. Their skin is greyish-brown to nearly black and is either smooth or with warty tubercles on the surface. The white or yellowish flesh is very aromatic and fragrant, with a soft and custard-like consistency. Mark Twain characterized this fruit as "deliciousness itself".[19]

The cherimoya is a very old fruit; it originated in the Andes of Peru and Ecuador.[20] It is now well-distributed throughout Central America, Jamaica, Brazil, Mexico, Cape Verde Islands, Hawaiian Islands,[21] the Campo Santo district in the province of Salta in Argentina,[22] the Mediterranean countries,[23]

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19 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 161.

20 Ibid., p. 168.

21 Ibid., p. 165.

22 Ibid., p. 165.

23 Ibid., p. 167.

India, and the province of Queensland of Australia.[24] Cherimoya is doing well in southern California, particularly in the foothills near the coast where it promises to be an important fruit.[25] It does not seem at home in southern Florida. In Madeira the fruit is replacing the grape as a commercial crop, where fruits weighing twelve to sixteen pounds each receive in the London market in normal times as much as $2.50 or $3.00 each, while those from three to eight pounds sell for $1.50 each. Only in a few places has commercial culture of cherimoya been undertaken.

The tree grows wild in much of the subtropics and is an orchard industry as yet on a small scale in regions of the Mediterranean type of climate. The cherimoya is essentially subtropical in its requirements and will not endure tropical conditions.[26] It attains perfection only where the climate is comparatively cool. In the tropics, therefore, it must be grown at considerable elevations. It will withstand winter temperatures of 26° F. when mature.[27] It succeeds best where the summer climate is relatively dry.[28] Rarely is the fruit tree successful on the seacoasts.

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[24] Op. cit., p. 167.
[25] Ibid., p. 168.
[26] Ibid., p. 169.
[27] Ibid., p. 169.
[28] Ibid., p. 169.

Annona cherimolia can be grown on light soils of many types, but prefers a rich loamy soil. Good soil drainage is of prime importance.

For commercial culture in California the trees are propagated by budding on seedlings of the cherimoya, while in Florida budding is done on Annona glabra which permits toleration of wet conditions. In Madeira the stocks are budded or grafted at two years of age.

Irrigation is needed at frequent intervals while the trees are young and less frequently, when mature.[29] Pruning is done to encourage productiveness. Pollination is a problem since the insect which does the work is yet unknown, and the unproductiveness of many of the trees may be due to a lack of the necessary insects.[30]

On the whole the trees are rather unproductive. Cherimoya begins to bear fruit three to four years after planting.[31] In California the main ripening season is in spring, usually March and April. When fully mature and ready to pick, the fruit has a yellowish tinge. If the fruits are to be shipped, they may be packed in hay or straw in a slatted package. They should be picked so as to reach their destination before they get soft.

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29 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 170.

30 Ibid., p. 173.

31 Ibid., p. 174.

Even after fifteen or twenty years the trees do not produce annually more than a dozen good fruits.

The cherimoya has not yet achieved the commercial prominence which it merits and which it seems destined some day to receive.

The Citron. The true citron (Citrus medica), commonly called the Persian apple, is the oldest of the citrus fruits, and is one of the best and most expensive of the condiments. The citron, usually six to ten inches long, is the fruit of a low spreading tree and resembles a small grapefruit except that it is elongated like a lemon with one end tapering to a point; it is fragrant and greenish-yellow in color, and exceptionally thick-skinned. The skin is tough and warty, and the acid pulp is scanty. Commercial citron is the candied rind of this fruit.

The citron dates back to the fourth century B. C. It probably originated in northern India and Persia, and has long been cultivated in southeastern Asia.[32] Persia still produces citron. The most important regions of production are located in the warmer parts of the Mediterranean Subtropical climate. Within the Mediterranean basin the citron has become one of the important fruits, large quantities being exported from the western and eastern ends. Corsica and Palestine have cultivated citron since early times; the most important portion of citron

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32 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 437.

production is in the western Mediterranean area, in Italy, Greece, and the adjacent Mediterranean islands of Sicily and Corfu. The Etrog or Sacred Jewish citron grows in Corfu and Palestine, bearing small greenish-yellow fruits which, if of the right size, sell for fancy prices, from $10 to $25 each.[33] Citron was introduced into the West Indies and Brazil by the Spanish shortly after the discovery of America.

The citron grows to a small extent in California and Florida. Only one or two commercial orchards exist there. It has been found to succeed well in the lemon districts of California. At present the citron industry in Florida has almost entirely died out. Small plantings of varieties cultivated in Europe were introduced into the southern and central parts of Florida. To increase citron production in the United States there is first a need of a greater demand for the fruit here; secondly, a protective tariff on peel imported in brine would be necessary to control prices of citron produced here.

Citron requires a warm climate throughout the year. It will stand but little cold, so is limited to frost-free areas, being very susceptible to frosts. In addition, an abundance of sunshine is necessary. The best of air drainage, with freely moving air, will do much to keep the trees in health. A well-drained soil in good tilth will satisfy citron, though it does

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[33] Samuel Fraser, American Fruits, Orange Judd Publishing Company, 1924, p. 668.

prefer a rich, easily worked, light loam.

Propagation of citron is by means of cuttings, layering, budding, or grafting, to be later planted in groves or orchards. The culture of citron is very similar to that of orange. Trees bloom and set fruit during all seasons of the year, bearing early. The fruit is harvested as soon as it reaches an adequate size.

Processing of the fruit consists of cutting the fruit in halves, removing the seed and pulp, and boiling the rind in brine to remove the bitter principle of the rind and bring out the flavor of the peel. Then, as a last step, it is desalted and candied in a sugar and glucose solution.

The United States imports cotron peel, both candied and in peel, from the western Mediterranean area, chiefly from Corsica, Sicily, and Greece.[34] The United States in normal times takes one-third to one-half of the Mediterranean crop--2000 to 3000 tons.[35] Much citron peel is candied, principally in New York and Chicago. Northwestern Europe also consumes part of the Mediterranean citron crop.

In addition to citron peel candied for use in confections and cooking--a commodity restricted in its use--the essential oil of cedrat used in perfumery is expressed from the rind.[36]

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34 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 437.

35 Ibid., p. 437.

36 Ibid., p. 437.

The Fig. See pages 438 to 443.

The Grapefruit. See pages 443 to 448.

The Jujube. The jujube is one of the most promising of the orchard fruits for regions outside the tropics. Jujube (Zizyphus jujuba), a native of China, is a slow-growing, medium sized, thorny tree; its fruit is a reddish or dark-brown fleshy drupe, sometimes like an unripe cherry, sometimes like an olive, and it has a white, crisp, rich flesh.

Jujube can be grown in all tropical and subtropical countries. For thousands of years this fruit was cultivated in China, being now one of the five principal fruits grown there. It is now cultivated in China, the Philippine Islands, through the Malayan region and India, westward through Afghanistan, Persia, Arabia, Asia Minor, to the Mediterranean coast of France, Spain, and North Africa.[37] For commercial use the tree is promising in Georgia, Florida, California, Texas, and other southwestern states, as well as in Mexico.

Certain environmental factors favor the growth of this tree. No weather appears to be too hot for it. It has been known to endure temperatures of 110° F. in the summer. The tree does best in brilliant sunshine,[38] and long intensely hot summers

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[37] Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 383.

[38] Samuel Fraser, American Fruits, Orange Judd Publishing Company, Inc., 1924, p. 733.

of dry weather. Under such conditions it bears regularly, easily, and abundantly. Since the trees bloom in June, there is no danger from frost. So the whole of the southwestern part of the United States with the exception of the elevated areas where cold summer nights occur is a promising region.

This tree will grow on all kinds of soils except heavy clay, and it will not thrive in wet locations.[39]

The climatic conditions of the Mediterranean Subtropical climate are best suited to this fruit, though the tree will grow in certain parts having the Arid Subtropical climate.

Although propagation may be from seeds, green wood cuttings, sprouts, root cuttings, budding, or grafting, the use of sprouts is probably the easiest since they are formed in abundance. The seeds are quite hard and it is advisable to crack them, for if not cracked, they may require two years for germination. Cultivation and care is similar to that given citrus fruits, except that the plants do not need much irrigation.[40]

The trees come into bearing quickly, sometimes when one year old, but more generally it takes three or four years.[41] The fruiting is annual and the bearing habits are regular. Jujube trees decline in vigor after twenty-five or thirty years, and rarely live over forty years.

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39 Op. cit., p. 735.

40 Ibid., p. 733.

41 Ibid., p. 733.

For eating fresh or preserving, or for making glacé fruit, the jujube is gathered as soon as ripe--from October to December--and is then mahogany colored.[42] For drying, it may be allowed to hang until it turns darker and dries somewhat, which is attended by a wrinkling of the skin. Such fruit, if further dried in the sun, may be kept for a year or more. Prepared jujubes are as delicate in flavor as many of the dates.

The Lemon. See pages 448 to 453.

The Loquat. See pages 453 to 456.

The Orange. See pages 466 to 475.

The Peach. See pages 475 to 481.

The Pomegranate. An interesting but as yet relatively unimportant fruit in world trade is the pomegranate. The tree (Punica granatum) is a native of western Asia, believed to be Persia,[43] though some claim Palestine and the Mediterranean region to be the native home of this tree. The fruit is round, berry-like, brownish-yellow or reddish, and about the size of an orange. They have a hard leathery rind, an edible pulp with amethyst colored juice and many seeds.

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42 Samuel Fraser, American Fruits, Orange Judd Publishing Company, 1924, p. 735.

43 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 457.

Pomegranates have been widely introduced and raised in arid subtropical and subtropical regions of the world, being a typical Mediterranean fruit.[44] It is a common fruit in northwestern India, Afghanistan, Persia, Mesopotamia, Arabia, near the Mediterranean shores of both Europe and Africa, more particularly in the latter. In America the tree is scattered from southern United States to Chile and Argentina.[45] This fruit is now a marketable crop in parts of the United States, reaching greatest perfection in subtropical regions of California, Arizona, New Mexico, and in the arid regions of Utah and Nevada.[46]

While the pomegranate can be grown throughout the tropics and subtropics, it produces good fruit only in semi-arid regions where high temperatures accompany the ripening season. In this respect it resembles the date palm, although it is less exacting as regards heat than the latter, and is more frost resistant. No climate seems too hot for it, but it cannot endure temperatures which are lower than 8° to 15° F. without serious damage.[47] Pomegranates from desert regions where the total amount of heat is high have the best flavor and color, and excel in quality. Wherever the trees are exposed to cool sea

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44 Samuel Fraser, American Fruits, Orange Judd Publishing Company, 1924, p. 784.

45 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 377.

46 Ibid., p. 377.

47 Op. cit., p. 784.

breezes, the trees do not bloom well or set much fruit, and then are usually sour, tart, and poorly colored. The pomegranate thrives better at higher altitudes than on the seacoast, at altitudes of 4000 feet, between the 41st parallel of South Latitude and the 41st parallel of North Latitude.[48]

The moisture requirement is about that of peaches or apricots--from 35 inches to 40 inches[49]--necessitating irrigation for production of good yields where the rainfall requirement is not met. Like the palm, it requires plenty of water at the root if good fruit is to be produced in abundance. Nevertheless, it is able to withstand long periods of drought. On the other hand, excessive moisture does not seem as detrimental to the pomegranate as to many other fruit trees.

In regard to soil, the species is not exacting, but is considered to succeed best on deep, rather heavy loams. It is on soils of this type that the excellent pomegranates of Mesopotamia are grown.[50] However, it is found that this fruit tree thrives on soils ranging from pure sand to heavy clay. A small amount of alkali is not injurious.

Pomegranates are propagated relatively easy from seed, cuttings, layering, or grafting. Under good cultural conditions

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48 Samuel Fraser, American Fruits, Orange Judd Publishing Company, 1924, p. 784.

49 Ibid., p. 785.

50 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 378.

the tree comes into bearing at three to four years of age.[51] The trees are long-lived, certain specimens having been known to bear fruit for over two hundred years. A properly grown tree of mature size may yield two hundred to four hundred pounds of fruit. An acre may, therefore, yield as much as twenty-five tons of fruit.

The fruit matures from September to January. On account of the common habit of splitting, most of the fruit is harvested before fully matured.[52] This necessitates several pickings at intervals of about a month. The fruit is clipped rather than pulled off so as not to bruise the fruit in any way. After the fruits are gathered, they are stored in a cool, dry place where the flavor becomes richer, the rind thinner and tougher, the amount of rag diminishes, and the seed coat becomes more tender and edible.

On the whole this fruit is not an important one in world commerce.[53] For a long time it has been imported in small quantities into Great Britain from Portugal and North Africa. Pomegranates are a very refreshing fruit, and are used as a table or salad fruit as well as in beverages.

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51 Op. cit., p. 378.

52 Ibid., p. 378.

53 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 373.

The Plum and Prune. "All prunes are plums, but not all plums are prunes" is another way of stating that the plum industry has two divisions: the fresh-fruit industry and the prune or dried-fruit industry.[54] The fresh-fruit (plum) industry is widely distributed over many temperate countries and climes; the dried-fruit (prune) industry, however, is largely centered in the cool and moist margins within or close to the Mediterranean Subtropical climatic regions, and is the climatic region in which the greater part of the world's commercial plums is derived. Because the prune is the most important commercial plum,[55] both phases of the plum industry will be discussed here as a matter of convenience.

The plum (Prunus spp.) is a thick-fleshed fruit, with a somewhat flattened, pointed stone and with a smooth skin cover having a whitish bloom, usually bluish in color. This fruit is grown on a small tree usually ten to twenty-five feet in height. There are some fifteen different species of plums, four of which are grown in the United States. Of these the common or European plum (Prunus domestica) is the species of primary commercial importance in Europe and America, having been introduced into Europe from Asia Minor, its original habitat.[56] No other fruit,

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54 Brooks D. Drain, Essentials of Systematic Pomology, John Wiley and Sons, Inc., 1925, p. 125.

55 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 232.

56 Op. cit., p. 126.

not even the apple, has so wide a distribution at present in the temperate regions of the world.

Within the United States the plum has a wide geographic distribution, being grown in practically every state, but is commercially important in three regions: the Pacific Coast states, the Great Lakes area, and the Mississippi Valley.[57]

In the Pacific Coast states the greater part of the plum crop consists of those varieties which are grown for drying, called prunes. The term prunes is applied technically to plums which have been dried without removal of the seed; popularly, however, the term covers also the fresh fruit in the districts where the general practice of drying into prunes prevails.[58] Not all plums are suitable for drying into prunes, only those having such firmness and sweetness as to cure instead of spoil under natural drying conditions. Therefore, not all western plums are prunes. This region of the United States now supplies the home demand and yields an annual surplus for export which exceeds 175 million pounds.[59]

The plum and prune industry of the Pacific Coast states is located in three distinct areas. The Santa Clara Valley in

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57 Samuel Fraser, American Fruits, Orange Judd Publishing Company, 1924, p. 456.

58 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 487.

59 Ray H. Whitbeck and Vernon C. Finch, Economic Geography, McGraw-Hill Book Company, Inc., 1941, p. 93.

California (south of San Francisco) has one-third the plum acreage of the United States and produces one-fourth the commercial plum and prune crop; here alone nearly 200,000 acres are in prunes, representing a value of about $15,000,000.[60] It is the world's leading prune-producing center.[61] The Willamette Valley in Oregon produces large quantities of plums and prunes. In Washington smaller amounts are grown, particularly in the Puget Sound Lowland.[62]

In the Great Lakes area the type of plums grown are those used fresh. Regions of such production include western New York near Lake Ontario, northern parts of Ohio which border Lake Erie, and western Michigan east of Lake Michigan.[63]

The Mississippi Valley--including Iowa, Arkansas, Kansas, and parts of Texas grow plums which are used mainly for local markets--as are those of the Great Lakes area--for the fruit is soft and easily damaged in transit. In the southern part of this region the Japanese plum is a popular variety because of its wide adaptability to soils and climatic conditions. West

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60 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 232.

61 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 488.

62 J. Russell Smith and M. Ogden Phillips, North America, Harcourt, Brace and Company, 1940, p. 936.

63 Samuel Fraser, American Fruits, Orange Judd Publishing Company, 1924, p. 456.

of the Mississippi River native plums, especially Prunus munsoniana is the leading type.[64] Both are of secondary commercial importance at present, however.

Prunes are produced commercially in a few sections of central and southern Europe. Southern France, especially the district near Tours, was formerly the world's foremost prune-growing center.[65] Supremacy in Europe has, however, now passed to Jugoslavia where over 50,000,000 plum trees grow in Serbia south of the Sava River.[66] Other areas of prune-production include the Mediterranean countries of Spain, Portugal, and Turkey. In central Europe Germany also produces prunes. The Pacific states now produce more prunes than the whole of Europe.

Small amounts of prunes are produced in the Central Valley of Chile[67] and the southwestern parts of Australia--both regions having the Mediterranean Subtropical climate.[68]

Japan and China raise a variety called Japanese plums (Prunus salicina), supposed to be a native of China. This variety has been introduced into the United States with success.

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64 Brooks D. Drain, Essentials of Systematic Pomology, John Wiley and Sons, Inc., 1925, p. 129.

65 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 488.

66 Samuel Van Valkenburg and Ellsworth Huntington, Europe, John Wiley and Sons, Inc., 1935, p. 541.

67 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 141.

68 Leonard O. Packard and Charles P. Sinnott, Nations as Neighbors, The Macmillan Company, 1925, p. 302.

From a study of the above, it may be concluded that the prune is typical of the Mediterranean Subtropical type of climate regions of our Pacific states, Europe, Chile, and Australia; the plum as a fresh-fruit is grown in these places as well as in regions of Cyclonic types of climate.

Plum culture is an intensive orchard industry, especially where grown for prunes or to be sent in large quantities for the fresh-fruit markets.

Plums require that winters be not too severe; thus, they are generally distributed within the northern limit of apple culture in the East. Strong winter winds in the Mississippi Valley allow none but the native plum and Japanese plum to survive.

Twenty to forty inches of rainfall are needed by these trees. In the eastern half of the United States there is usually adequate rainfall for the plum crop. On the Pacific Coast irrigation is practiced where the summer rainfall is deficient.

Warm, dry weather during bloom time insures a good crop of fruit. At the harvesting period a dry season is very necessary, for rains during that time may cause the crop to rot on the trees. The Mediterranean Subtropical climate has such a dry period during the summer months and has been responsible for the development of the sun-drying of this fruit into prunes.

Plums grow on many kinds of soil--the requirement being that of good drainage. The Prunus domestica is usually grown

on rich, clay loams; the Japanese plum varieties are better adapted to light soils, sandy or gravelly loams.

Trees come into commercial bearing in four years in the West, and eight or nine years after planting in the East. Crops are produced annually: in the West trees yield for twelve years--"galloping through life"; in the East bearing continues for forty or fifty years, and the tree is said to "saunter through life".

The uses to which the plum is to be put calls for variation in their harvesting and handling. Except for certain parts of the Pacific Coast the handling of plums is not at all standardized. Because those in the eastern states are to be used for canning and sold fresh, they are harvested just before eatable while still somewhat green--a week or ten days before the fruit is fully ripe; the fruit in this stage is easier to handle, does not give the brown-rot fungus a chance to attack, and the flavor is best then for canning purposes. Western plums to be sent to distant fruit markets are picked half green so that they will arrive in the markets in the proper degree of ripeness.

For the prune industry the fruit is allowed to ripen on the trees until they drop, either with or without light shaking, being caught on sheets or upon straw, lawn clippings, or other soft material that will prevent bruising. The fruit is gathered weekly and harvesting is completed in a month's time.

Then the fruit is picked from the ground and taken to be dried (either in the sun or under artificial driers).

In California prunes are dried by two methods: sun-drying, made possible because of the hot, dry summers so characteristic of the Mediterranean Subtropical climate; and the dehydration processes which are now replacing sun-drying because of the greater certainty of operation and better grade of product which results. In Oregon and Washington prunes are dried by artificial heat, either steam or hot air. In other regions of plum production within the Mediterranean Subtropical type of climate prunes are dried in trays in the sun.

The procedure for sun-drying prunes takes ten to fourteen days. The fruit is put through a lye bath and is then run over a pricking board to hasten drying. Following this, the fruit is placed on large trays in the drying yard where it remains till the fruit is about three-fourths dry, being turned over at least once in that time. The dried fruit is then graded over screens, weighed, and counted. Before packing, the fruits are dipped in boiling water, after which they are packed. This method is followed in the Santa Clara Valley in California.

Drying prunes by artificial heat usually takes thirty-six hours, using steam or hot air. Then the fruit is stored in bins to sweat, after which it is processed or steamed to make the fruit soft and easy to pack. Packing is done while the fruit is still warm.

The northeastern and eastern parts of the United States and the northwestern parts of Europe are served by countries producing a surplus crop. The United States is supplied by its own regions of production as well as by imports in normal times from France and Jugoslavia. In 1935 the United States supplied 104,425 tons of fresh plums, 75 per cent of which was produced on the Pacific Coast.[69] In that same year the production of dried prunes was 280,000 tons (from our Pacific states); of this amount from 150,000 to 200,000 tons were produced in California.[70]

The Tangerine. See page 485.

GUMS AND RESINS

Hard Resins

Mastic. Mastic, Chios mastic, mastic gum, or mastiche are the names applied to one of the most expensive and high-grade resins.[71] The source of this resin is Pistacia lenticus,[72] a small tree which is indigenous to the Mediterranean Coast region from Syria to Spain; the tree is also grown in Portugal, Morocco, and the Canaries. Production of the commercial resin is almost exclusively confined to the island of Chios (Greece),

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69 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 417.

70 Ibid., p. 417.

71 Ibid., p. 180.

72 Ibid., p. 179.

though small quantites are exported from the Moroccan coast, southern Europe, and Turkey.[73]

The resinous substance is contained in the bark of the tree, and in order to collect it numerous vertical incisions are made in the stem and main branches during June, July, and August when the heat of the hot, dry summers typical of these regions seems to exercise a great influence on the flow of the resin. Instead of making cuts into the tree in some localities the flow is aided by removing strips of bark.

The resin speedily oozes out and hardens, adhering to the branches or trunk in the form of oval, tear-like, straw-colored lumps, and if not collected in time, falls to the ground. In the latter state it acquires some impurities and consequently is less valuable. The oval tears are collected from the trees every fifteen days, being repeated several times between June and September. A tree yields about eight to ten pounds of mastic during the gathering season.

Throughout the Turkish Empire mastic is consumed in vast quantities as a chewing gum by women of all classes. At present mastic is chiefly useful in the arts as a varnish used for coating metals and pictures, both oil and watercolor, maps, drawings, etc. It is also used in lithographic work, in medicines, and as a cement or filler for cavities in dental work.

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73 J. Henry Wanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 307.

For these important uses the United States in 1935 imported 20,857 pounds of mastic.[74]

Sandarac. Sandarac, or sandarach, a friable, pale-yellow, almost transparent resin, is obtained chiefly from Tetraclinis articulata, a small coniferous tree popularly called the sandarac tree, also the tear tree. This tree is a native of northwestern Africa, Algeria and Morocco.[75] At present it is a characteristic tree of the Atlas Mountains in both Algeria and Morocco. An analogous resin is procured in China from Callitris sinensis, and in South Australia, under the name of pine gum, from Callitris reisii.

The resin is formed between the inner and outer layers of the bark of the tree, and is excreted in the form of small tears, quickly becoming opaque upon exposure to the air. Sandarac yields a hard, white, rather brittle spirit varnish, especially useful for coating labels, negatives, cardboard, leather, and metals; formerly it was used in medicine and was well known for this use in older civilizations.[76]

Sandarac is imported by the United States mainly from Mogador in Morocco (121,365 pounds in 1935), chiefly for use in the varnish industry here.[77]

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[74] Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 193.
[75] Ibid., p. 179.
[76] Ibid., p. 179.
[77] Ibid., p. 193.

Storax or Styrax. The most important type of storax or styrax, a balsamic-resin known as Levant styrax, is obtained from the inner bark of Liquidambar orientalis, a small tree common along the coasts of southwestern Asia Minor, a region which comes under the influence of the Mediterranean type of climate.

This balsam is a pathological product formed as a result of wound stimulation. The outer bark is bruised and soon the balsam exudes into the inner bark. After the outer layers are discarded, the balsam is recovered by boiling the inner layers in sea water. Styrax is a semi-liquid, grayish-brown, sticky, opaque substance with a pronounced aromatic odor. It is used in soaps and cosmetics, as a fixative for the heavy "oriental" type of perfume, in lacquers and incense, and as a flavoring for tobacco, in medicine as a stimulant to the mucous membranes, and for the treatment of scabies.[78]

OILS AND WAXES

Though no tree crop in the Mediterranean Subtropical climate furnishes a wax, a number of them furnish oils, both fixed and essential (for the difference between the two see page 200). The pulp of the olive supplies an edible oil (fixed); the rind of citrus fruits, especially the orange and lemon, the flowers of both the bitter and sweet orange, and the kernels of almonds, pistachios, and walnuts furnish a number of essential oils used

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[78] Op. cit., p. 188.

for flavoring extracts and in perfumery. Though the citrus fruits are cultivated for the most part in both the Mediterranean and Humid Subtropical types of climate, the manufacture of these essential oils--almond oil, bergamot oil, lemon oil, oil of neroli, orange oil, pistachio oil, and walnut oil--is confined importantly to regions of the Mediterranean climate.

Fixed Oil

Olive Oil. The olive (Olea europaea)[79] is one of the oldest and most useful of fruits, and has, therefore, been recognized as one of the most valuable of tree crops. It is the most valuable Mediterranean tree. Its purplish-black, one-seeded fruit is used mainly for making olive oil, but it does have some importance as a fruit to be pickled. In the Mediterranean lands innumerable people eat nothing but bread and pickled ripe olives for meal after meal; in such regions it is a principal article in the diet.

The olive tree is a native of Asia Minor and appears to have been one of the trees earliest cultivated by man.[80] At present it is practically confined in its cultivation to lands with the Mediterranean Subtropical type of climate; it is the most characteristic crop of this climate. Olive orchards and

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79 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 482.

80 Ibid., p. 482.

groves are concentrated in the valleys and along the coasts bordering the Mediterranean Sea, stretching from end to end of the Mediterranean Basin. Spain, Italy, and Greece produce more than 80 per cent of the world's commerical olive crop, with Tunisia and Portugal trailing by a wide margin; Algeria and Syria complete the list of Mediterranean countries which produce olives.[81] In Spain all parts, except the northwestern portion where the altitude and rainfall combine to prevent the growth of olive trees, have numerous olive trees; the province of Granada is especially important in olive production in that country. The westward facing slopes and river valleys of Portugal contain large numbers of these trees. The central and southern parts of the Italian peninsula are covered with olive groves and orchards, with the best olives produced in the extreme northwestern part of the Riviera, near Florence; but the tree shuns the Po Valley and so that region of Italy is excluded from olive production because of adverse climatic conditions.[82] The Matmata section of central Tunisia, the Peloponnesus (the peninsula south of the Gulf of Corinth) in Greece, the coastal lands of northern Algeria and Morocco, the fertile coastal plain of Palestine and Syria, and the westward facing slopes on the coastal areas of Anatolia complete the list of

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81 Op. cit., p. 484.

82 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 266.

localities important in olive production within the Mediterranean Basin.

Outside the Mediterranean Basin the Imperial Valley and northern part of the Sacramento Valley of California is the only other important center of olive production.[83] Olives raised here are the best of any in quality, but the quantity, though increasing, is less than 5 per cent of the world's total.[84] The reason for more olives not being grown in the United States is because of the rate of wages. Picking olives and making olive oil requires a great amount of work by hand; and this can be done in Europe where labor is plentiful and cheap, but workers in California demand high wages. As a result American olives cannot be marketed profitably in competition with European olives.[85] Therefore, a Californian farmer prefers to raise oranges, lemons, etc. with large cultivators, sprayers, and other machines drawn by tractors rather than a crop that requires a great deal of hand labor for which high wages must be paid.

Other regions of the Mediterranean climate in which olives are cultivated to some extent include southwestern Australia and the southern tip of Africa.

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83 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 484.

84 Ibid., p. 484.

85 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 374.

Olives are best adapted to the Mediterranean Subtropical climate of wet, mild winters and hot, dry summers. The tree can thrive on a small amount of moisture and can stand protracted drought. The tree needs a winter rainfall of at least ten to fifteen inches.[86] Too much moisture is unfavorable because the fruit diminishes in succulence under those conditions. Since the olive has deep, large widespread root systems, they can live through dry summers without irrigation because they can get water from great depths and from the immediate subsurface area even after a light shower.[87] Thick leather-like leaves, hairy below, and the thick bark of the tree retards evaporation during the dry summer months.[88] The olive is thus one of the neatest adjustments to the environment.

The Olea europaea is very sensitive to the cold of winter, and hence is distributed only in the milder portions of the Mediterranean regions where there is freedom from frost. Temperatures averaging 57° F. and never going below 14° F. are desirable.[89] In California the prevailing winds from the Pacific are much above freezing temperatures, and the high Sierras

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86 Op. cit., p. 373.

87 C. Langdon White and George T. Renner, Geography: An Introduction to Human Ecology, D. Appleton-Century Company, Inc., 1936, p. 104.

88 Ibid., p. 104.

89 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 453.

effectively shut out winds from the cold, dry interior.[90]

Any soil satisfies the olive provided it is well-drained and deep enough so that the roots may draw on the moisture in the lower soil levels during droughts. Olives thrive well in thin calcareous soils, tenacious clay on slopes, sandy and gravelly piedmont plains, or alluvial fans if the drainage is satisfactory.[91] Light, limey soils are the best, and the quality of the fruit is greatly influenced by the soil conditions. Olives will grow on rugged, unirrigable lands, on hillsides, and even thrives in poor and stony ground. Considerable areas in the Mediterranean region now covered with valuable olive orchards would be of little value if the olive shunned such localities, for they are unsuited to other agricultural enterprises.

The growing of olives in cultivated orchards and groves is a phase of agricultural activity. In Mediterranean countries of Europe and Africa olives are raised from seed, but in the United States they are propagated by cuttings. In about three years the trees begin to bear fruit, but does not reach profitable production until the eighth year.[92] A tree four

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90 J. Russell Smith, Men and Resources, Harcourt, Brace and Company, 1937, p. 144.

91 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 262.

92 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 482.

years old produces about five pounds of fruit; those ten years old produce 250 to 650 pounds per tree.[93] The fruit comes but once every two years, but the tree bears for many years--for several hundred years or more.[94] Groves or orchards in profitable production furnish twenty to forty gallons of oil per tree.[95]

The harvesting of the olive crop comes at the beginning of the winter rains, in the Northern Hemisphere usually in November and lasts until spring.[96] The use of the olive determines the time of harvesting. For pickling green, the olives are picked when fully grown but before any color appears. For ripe pickles or oil the olives are picked when they turn dark but not black.

High quality olives are picked by hand, but in many of the older producing sections, such care is not practiced, the fruit being shaken from the trees by beating the branches with poles, and the olives picked from the ground in a more or less bruised condition. The latter method lowers the quality of the oil and causes undesirable flavor to develop.

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93 Samuel Fraser, American Fruits, Orange Judd Publishing Company, Inc., 1924, p. 766.

94 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 483.

95 Ibid., p. 482.

96 Ibid., p. 483.

Much labor is involved in harvesting olives, as well as in the preparation of pickled olives and in the extraction of olive oil. Around the Mediterranean region plenty of cheap labor is available, but in the new olive lands of California, Arizona, and New Mexico, labor is scarce and expensive.[97] Therefore, here it only pays to produce the expensive pickled green olives.[98]

After picking, the fruit (if oil is to be extracted) is spread out and slightly heated, then ground into a pasty mass. This is next subjected to a heavy pressing until all the oil is exhausted, then put into large casks or hogsheads, and sent to the United States and northwestern European countries where it is put into cans and bottles. Fresh olives play no part in foreign trade because the oil must be extracted while the fruit is still fresh, and also the worthless stones and pulp are so bulky that it would be foolish to ship them any distance.

In the United States most of the olives are grown in California, though the industry is extending into Arizona and New Mexico. In 1935 the United States grew 56,000,000 pounds of olives.[99] The price of olive oil makes it cheaper to import it than to grow it, and so this limits olive production in the

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97 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1935, p. 374.

98 Ibid., p. 374.

99 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 454.

United States to small amounts used in other ways. Labor in this country is scarce and expensive, so the cost of producing olives is high. The standard of living in this country is so high that butter and meat are used for carbohydrate foods and olive oil is not in great demand for food purposes. Therefore, in California the olives are picked when ripe, chiefly for use in pickling and canning, and only the poorer ones are used for oil. About 5,000,000 pounds of oil are produced yearly in this country.[100] Olives might be grown more extensively on much of the rough land near the heads of alluvial fans in the western portions of the United States, but it cannot be raised in competition with European olive oil and other vegetable oils.

A large portion of the Mediterranean olive crop is used for local consumption. In that region pickled ripe olives are a principal article in the diet and olive oil takes the place of butter for cooking because climatic conditions are unfavorable to dairying. Olive exports are chiefly to the United States and countries of northwestern Europe. The United States purchases 90 per cent of its pickled olives from Spain and 70 per cent of its edible oil from Italy.[101]

The better grades of olive oil are consumed as salad oil or as substitute for butter in cooking. The poorer grades are used in spinning and weaving, in soap manufacture, for ointment

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100 Op. cit., p. 219.

101 Ibid., p. 219.

on hands and face as a protection against hot sun and dry wind.

Essential Oils

Almond Oil. The bitter almond (Prunus amara) grows chiefly in the Mediterranean regions of southern Europe. This variety of almond is used primarily for the manufacture of almond oil and flavoring.[102] The oil is obtained by grinding the kernel of this nut with water and then subjecting this mass to distillation.[103] For further discussion on the almond refer to page 410.

Bergamot Oil. Bergamot oil is a greenish oil expressed from the rind of the bergamot orange (Citrus bergamia).[104] This oil has a soft sweet odor and is used extensively in the United States for scenting toilet soaps, and in the manufacture of mixed perfumes. This oil is manufactured chiefly in Calabria in southern Italy and also in Sicily.[105] The United States in 1935 imported from these regions 99,270 pounds of bergamot oil.[106]

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102 William G. Freeman and Stafford E. Chandler, World's Commercial Products, Ginn and Company, 1911, p. 297.

103 Ibid., p. 361.

104 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 201.

105 Op. cit., p. 361.

106 Op. cit., p. 209.

The contrivances for extracting the oil are very crude, much hand labor being necessary. The fact that labor in Italy and Sicily costs only one-third as much as in California is the chief reason why California does not produce large amounts of this citrus oil.[107]

In Calabria a crude machine is used in which is a bowl lined with sharp metal points. The fruit is placed whole in this bowl and revolved, the points puncturing the peel, from which the oil drips through an opening in the bottom of the bowl. This device is called an ecuelle, and is used chiefly in making of bergamot oil, for the reason that bergamot oranges are round in shape and revolve to better advantage in the machine than any other citrus fruit.[108] A few operators lacerate the rinds of the bergamot orange and distill the oil, but the use of this method results in a water-white oil of inferior grade.[109]

Lemon Oil. Lemon oil is prepared principally in Sicily from the rind of the lemon (Citrus limonia) by the expression process: the chief center of this industry is Messina.[110] From this district the United States imported 131,043 pounds of lem-

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107 J. Eliot Coit, Citrus Fruits, The Macmillan Company, 1915, p. 334.

108 Ibid., p. 335.

109 Ibid., p. 335.

110 William G. Freeman and Stafford E. Chandler, World's Commercial Products, Binn and Company, 1911, p. 361.

on oil in 1935.[111]

The expression of the oil of lemon is an important industry in Sicily, where the sponge method is used.[112] The fruits are cut in halves or quarters, and the adhering acid pulp removed. The peels are soaked in cold water for a few hours to increase the turgidity of the cells. The portions of the rind are then either squeezed against a sponge held in the right hand of the operator, or, in the case of halves, are pressed against it and rotated. In this way the small cells in which the essential oil is secreted are broken and as the oil exudes it is absorbed by the sponge. When the latter becomes saturated, the oil is squeezed out into a receptacle. After the oil is filtered through a paper filter, it is ready for market.[113]

It takes 800 to 1100 lemons to yield one pound of oil.[114] Lemon oil is used in making lemon extract which is next to vanilla in importance as a flavoring substance; the oil for this use, however, comes largely from the seeds of lemons, as well as from the rind of the fruit.

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111 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 209.

112 William G. Freeman and Stafford E. Chandler, World's Commercial Products, Ginn and Company, 1911, p. 360.

113 J. Eliot Coit, Citrus Fruits, The Macmillan Company, 1915, p. 335.

114 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 436.

Oil of Neroli. Oil of neroli is used extensively in blends and for mixing with synthetic perfumes. It is obtained by distilling the flowers of the bitter or bigarade orange (Citrus aurantium) and the sweet orange (Citrus sinensis).[115] True oil of neroli is made from the former chiefly in the vicinity of Grasse in the French Riviera (southern France);[116] from the latter, in Portugal. Other Mediterranean countries also produce smaller quantities of this oil.

Both oil and water pass through the still; and as they condense the oil collects on the surface, is skimmed off, and sells for a very high price (from $20 to $50 a pound).[117] Three hundred pounds of orange flowers are required to make one pound of neroli.

Imports of true oil of neroli, or neroli bigarade, amounted to 694 pounds in 1935,[118] coming mainly from the Mediterranean countries. The high cost of labor accounts for the lack of production in the United States.

Orange Oil. This oil is obtained by the same methods used for getting lemon oil and bergamot oil (see page 394 for the former, and page 393 for the latter). Orange oil is made chief-

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115 Op. cit., p. 201.

116 J. Eliot Coit, Citrus Fruits, The Macmillan Company, 1915, p. 338.

117 Ibid., p. 338.

118 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 209.

ly in Calabria in southern Italy, Sicily, and southern France, from the rind of the sweet orange, Citrus sinensis.[119] The most important use of the oil is as a perfumery agent.[120] For a complete discussion of the cultivation of Citrus sinensis see pages 466 to 475.

Pistachio Oil. See pages 427 to 430.

Walnut Oil. The kernels of the common walnut tree, Juglans regia, when pressed give about 40 per cent to 50 per cent oil. This oil is used as a medium for paints. Fresh cold-pressed oil is suitable for edible purposes.[121] Further information on the walnut--its geographic distribution, requirements, and cultivation--will be found on pages 422 to 427.

SPICES AND FLAVORING MATERIALS

The Mediterranean Subtropical climate has no tree which furnishes a spice, but several provide flavoring materials which are used in cooking, confectionery, and ice-cream: almond oil, apricot-kernel oil, lemon oil, orange oil, peach-kernel oil, and pistachio oil.

Flavoring Materials

Almond Oil. See pages 410 to 415.

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119 William G. Freeman and Stafford E. Chandler, World's Commercial Products, Ginn and Company, 1911, p. 361.

120 Ibid., p. 361.

121 Ibid., p. 367.

Apricot-kernel Oil. See page 362.

Lemon Oil. See page 394.

Orange Oil. See page 396.

Peach-kernel Oil. See page 481.

Pistachio Oil. See page 430.

TANNING MATERIALS

Within the Mediterranean Subtropical type of climate three tree crops furnish tannin: the leaves of the Sicilian sumach, the sun-dried acorn cups of the Turkish oak (valonia), and the bark of the California tanbark oak.

Sicilian Sumach. The only leaf used as a tanning material and produced in commercial quantities of importance is the Sicilian sumach (Rhus coriaria).[119] Its leaves when dried contain 20 per cent to 35 per cent tannin.[120]

Rhus coriaria is a native of the Mediterranean regions of Europe.[121] The tree now grows chiefly in Sicily and southern Italy, where it is extensively cultivated; it is also found in

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119 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 139.

120 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 64.

121 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 330.

other sections of the Mediterranean Basin.[122] The cultivation of Sicilian sumach is, therefore, a natural Italian monopoly. Other foreign varieties of sumach from Austria and eastern Europe have endeavored to compete against Sicilian quality, but have been unsuccessful on account of the inferior color effect on leather.

The area within which the Sicilian sumach is cultivated is restricted by climatic requirements to the better parts of the Mediterranean Subtropical climate. A lack of rain and unseasonable developments affect adversely the crop of leaves and create world shortages. The tree flourishes to good advantage on the dry, stony soil of the Mediterranean Basin. Under such conditions the tree, in a wild state, reaches heights of fifteen to twenty feet; under cultivation they seldom are more than four feet.[123]

During the second or third year of growth the leaves are plucked, dried, and ground in stone mills until a fine powder or dust is produced.[124] Leaves of the Sicilian sumach yield a tannin until the tree has reached its fifteenth year, when the yield of tannin ceases.[125]

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122 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 64.

123 J. Henry Vanstone, The Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 330.

124 Ibid., p. 330.

125 Ibid., p. 330.

Palermo, in northwestern Sicily, is the chief distributing center of Sicilian sumach.[126] The United States is the largest buyer of this tanning material; in 1935 purchases of 5,651,520 pounds of the powder or dust, and 5,864 pounds of the extract were made.[127] France, Great Britain, and Germany in normal times are also active purchasers.[128]

Sumach tannin is used principally for tanning fine leather (sheepskin) for gloves and book-binding because of the light color and soft flexible quality of leather produced.

Tanbark Oak. The California tanbark oak (Quercus densiflora) is a native of southern Oregon and of California, where the harvesting of the bark for tanning has been an important industry since 1850.[129] This species of oak has an exceedingly high tannin content--up to 29 per cent[130]--and is of increasing importance.

The tree ranges from southwestern Oregon along the coast ranges to Santa Barbara in southern California,[131] a region hav-

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126 Wilbur J. Page, Tanning Materials Survey, Trade Information Bulletin No. 167, Bureau of Foreign and Domestic Commerce, 1924, p. 5.

127 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 152.

128 Op. cit., p. 6.

129 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 75.

130 Ibid., p. 64.

131 Ibid., p. 75.

ing the characteristics of the Mediterranean Subtropical type of climate.[132]

Much of the supply of the Santa Cruz district of northern California was practically exhausted by 1900. The largest remaining available supply is now in northern Mendocino and Humboldt Counties.[133] It is estimated that at the present rate of cutting, the supply here will last only until 1965.[134]

The bark-peeling season is usually from May 20 to August 10, but it varies with the weather, altitude, and temperatures. This oak is extremely sensitive to heat and cold, and a cold spring will delay the opening of the peeling season. Cold weather causes the bark to adhere closely to the tree. The time required by two men to peel a large tree is about one-half day. Peelers strive to complete the peeling during the day, as the bark may tighten if left over night.

In peeling, the tree is first girdled, felled, and the bark is removed in four foot sections.[135] The bark is removed up to a point about one-half inch in thickness on the trunk. A pair of workmen on the average commonly peel two cords of bark

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132 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 614 (Plate I).

133 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 75.

134 Ibid., p. 75.

135 Ibid., p. 76.

a day.[136] Sometimes bark from standing trees is removed as far as it can be conveniently reached, and the rest of the tree is left to die, but this is a more wasteful method than the former.

About one and one-fourth to two and one-half cords of bark are produced per acre stand of trees; six average trees will make a cord of bark in the most important producing sections.[137]

Valonia. Valonia--Smyrna valonia and Greek valonia--is the usual commercial name given to the tanning material furnished by the sun-dried acorn cups of the Turkish oak (Quercus aegilops), a tree native to the eastern Mediterranean region, particularly Asia Minor and Greece.[138] This oak now grows chiefly in Turkey and Asia Minor, and to a less extent in the Greek Archipelago and the forested hillslopes of those Balkan countries, all of which are under the influence of the Mediterranean climate. The Balkan countries, which produce a minor part of the export product, export yearly several million dollars worth of valonia.[139] Smyrna valonia is considered the best kind and its solid extract contains about 60 per cent of tannin.

The valonia industry is controlled by Greek capital, and the bulk of valonia is shipped to the United States in normal

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136 Op. cit., p. 75.

137 Ibid., p. 75.

138 Wilbur J. Page, Tanning Materials Survey, Trade Information Bulletin No. 167, Bureau of Foreign and Domestic Commerce, 1924, p. 7.

139 J. Russell Smith, Commerce and Industry, Henry Holt and Company, 1925, p. 499.

times. Both the raw material and extract are imported: of the former, in 1935, a total of 22,313,274 pounds were imported; of the latter, in the same year, 2,803,470 pounds.[140] Great Britain is a large importer, also. In normal times valonia is in great demand in Austria and Russia for the tanning of the fine leathers there.[141]

These acorn cups may contain up to 45 per cent tannin. The tannin is readily derived in the form of an extract from the coarse hair or beard which covers each cup and which is especially rich in the tannin. In tanning this material is seldom used alone as it has an injurious effect on leather; but excellent results are obtained when used in combination with other tanning materials. Valonia is used extensively in the preparation of sole leather as well as for tanning finer grades of leather.

TREE LEGUME AND EDIBLE NUTS

A tree legume known as the carob and a number of nuts--the acorn, almond, chestnut, filbert, Persian or English walnut, and pistachio nut--are all produced by trees which are at home in the Mediterranean Subtropical type of climate. Both the tree legume and the nuts are edible, serving as man-food and stock-

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140 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 152.

141 J. Russell Smith, Commerce and Industry, Henry Holt and Company, 1925, p. 499.

food.

Tree Legume

The Carob. The carob is to the Mediterranean what corn is to our Central Plains. It may be called a stock-food tree as well as a man-food tree since it supplies seeds and pods which are highly prized in some parts of the world as a food for animals and even for man.

The flat, bean-like pods, from four to twelve inches long, are borne in large numbers by the carob tree (Ceratonia siliqua) which is believed to be a native of the southern coast of Anatolia and Syria,[142] but which has been cultivated within historic time in the countries of the Mediterranean Basin.

From its native habitat the carob was introduced into other parts of the Mediterranean region. The carob is to be found cultivated in regions hugging close to the seashore in the hotter parts of the Mediterranean lands, and is especially important in various Mediterranean islands. The countries and islands in which it is cultivated abundantly include eastern Spain, southern France, Sardinia, southern Italy, Greece, Syria, Palestine, Cyprus, Sicily, and northern Algeria.[143] The carob is of greatest commercial importance in Cyprus where 1924

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142 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 337.

143 J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p. 45.

statistics reveal a per capita export value of $4.[144] This tree was introduced into southern California which has climatic conditions similar to that of the Mediterranean Basin. Here it is still in the introductory stage though some commercial plantings have been made, particularly in the Imperial and Coachella Valleys, where the winters are mild.

Carob thrives only in regions of the Mediterranean type of climate. It requires the same climatic temperatures as the orange (See page 467.); it is injured by winter temperatures of 20° F., or even a little above.[145] Therefore, the carob is limited to approximately those lands where the temperature conditions are suitable to the orange. Because it is easily injured by frosts, the carob keeps close to the shore. Large areas of California are climatically adapted to the carob, and plantings are being developed in the foothills of the Sierra Nevadas. When once established, the carob is more resistant to frost than the orange. Because the developing fruit is liable to be killed by frost later on, successful production of carob pods in interior valleys is practically limited to the citrus belts along the foothills.

Carob thrives on any soil except stiff clays.[146] It pre-

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144 Op. cit., p. 46.

145 Ibid., p. 47.

146 Ibid., p. 47.

fers to grow on land that is too dry and rocky for the orange. Because of this, the carob is suited to steep rocky hillsides and semi-arid lands.[147]

This tree does not thrive where there is much humidity.[148] It is drought-resistant and once started, it thrives without irrigation; it will grow in arid localities where the rainfall is only about ten inches. The roots of the carob extend as far as sixty feet in depth to reach underground water. California has a large area with orange temperatures, but because the orange trees are water hogs, the major protion of California having orange temperatures cannot be orange land; but much of it may become carob land since this tree can survive and even bear a light crop in a rainless summer where there is no irrigation to allow orange production.[149] It is claimed that California has 500,000 acres of such land suited for carob.[150]

The carob is planted from seed, transplanted to the field when three feet high, and budded the next year. Some bear fruits four to five years after budding. Commercial bearing begins from the tenth to the twelfth year, reaching full bearing between the twentieth and fortieth years. The tree blooms

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147 J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p. 47.

148 Ibid., p. 47 (footnote).

149 Ibid., p. 56.

150 J. Russell Smith and M. Ogden Phillips, North America, Harcourt, Brace and Company, 1940, p. 656.

in autumn and carries the young fruit until late the next summer.[151] It bears annually and continues for generations, even hundreds of years. The carob is very productive and has an exceedingly high yield. Each tree yields anywhere from 110 to 800 pounds.[152]

Cyprus annually exports thousands of tons of carob to Europe for stock feed. In 1935 the United States imported from the Mediterranean countries 1,234,316 pounds of carob for various uses.[153]

In the United States carob is used in flavoring dog biscuits and chewing tobacco. Because the dried pods contain 50 per cent sugar, they are used in making syrups, candy, cereal, and commercial animal foods. Carob pods are often sold in cities to be eaten like candy. One pound of carob makes one full pound of carob syrup which is considered far superior in flavor to maple syrup.[154] Ground-up seeds yield a highly nutritious meal. Several bakeries are now making a bread containing 25 per cent carob flour. In the Mediterranean countries carob is a stock-supply crop--like corn on American farms--to be fed to farm animals, hogs and cattle, and even to some extent for man.

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151 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 362.

152 J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p. 49.

153 Op. cit., p. 362.

154 Op. cit., p. 53.

Edible Nuts

The Acorn. The acorn--another of Nature's tree offerings to man and beast--is a nut characteristic of oak trees (Quercus spp.) which grow in the temperate parts of Europe and North America. Most people look upon the acorn merely as an interesting product of the oak tree; some think of it as food for swine. Very few realize that many people in the countries bordering the Mediterranean Sea rely on acorns as a substantial part of their food supply.

Acorns attain their greatest commercial importance in the Mediterranean countries, though their production is by no means wholly limited to that climatic area. The evergreen oaks (Quercus ilex, Q. suber, and Q. occidentalis) furnish the acorns which account for 20 per cent of the sustenance of the poorer classes in Italy and Spain,[155] in the form of acorn bread and cake; it is highly nutritious, cheap, and keeps indefinitely. In many places in the Mediterranean area the acorn has been improved until it is almost as good as the chestnut.[156] The acorn has been used for fattening swine from time immemorial; acorns now produce half the pork of Portugal since the hogs range the forests and eat the acorns, which the swineherds lash

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155 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 381.

156 Ibid., p. 381.

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155 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 381.

156 Ibid., p. 381.

from the trees with long whips.[157] Thus, the swine harvest the crop and feed and fatten themselves in the process.

These evergreen oaks (including the cork oak) are the only large trees in the forests of the Mediterranean area. The oak forests are very open. Most of the trees are of native origin and grow wild.[158] On the mountain slopes where the rainfall is heavier the forests are denser. The trees usually grow on the lower slopes of mountains, and on the poorer and more rocky soils which are unsuited to agriculture. The Mediterranean countries with oak forests which supply a crop of acorns include Spain, Portugal, Italy, Algeria, Tunisia, southern France, Morocco, Corsica, and Sardinia, and to a more limited extent in Greece, the Dalmatian Coast, Tripoli, and Asia Minor.

The oak trees of the Mediterranean are very slow in growth, bearing their first crop after twenty years. They are, however, long-lived (100 to 500 years)[159] and very productive--producing as much as 750 quarts of acorns per tree.[160]

These oaks are all evergreens; all have features which show their adjustment to the hot dry summers of the Mediterra-

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157 J. Russell Smith, Commerce and Industry, Henry Holt and Company, 1925, p. 520.

158 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 434.

159 Ibid., p. 435.

160 J. Russell Smith, Commerce and Industry, Henry Holt and Company, 1925, p. 651.

nean type of climate which exists there: small, spongy, velvety, holly-like leaves which reduce transpiration; strong, wide-spreading root system which often comes above the surface of the ground in order to obtain moisture from as large an area as possible, as well as to collect for the tree whatever light rainfall may fall on the ground surface.

The Almond. The almond--the peach without juice--is grown on a small tree (Amygdalus communis).[161] The almond fruit is an inedible drupe, with a tough fibrous rind surrounding the stone (shell) and the seed (nut). There are two main kinds of almonds: sweet almonds, which have an edible seed and are the source of the commercial product; and the bitter almonds, which are used primarily for manufacturing almond oil and flavoring. Of the two kinds the sweet almond is of far greater value commercially than the bitter almond.[162]

The almond is a native of the Black Sea district of Asia Minor and the countries of the eastern Mediterranean Basin.[163] Today the world's almond crop is almost exclusively confined to areas of the Mediterranean type of climate--such as California,

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161 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 218.

162 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 297.

163 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 380.

Spain, Italy, Morocco, Algeria, Sicily, Syria, and Palestine, with lesser amounts being produced in the Central Valley of Chile, South Africa, and South Australia.[164] About 99 per cent of the United States' crop of almonds is produced in the state of California, mainly in the interior and coastal counties, where there are approximately 100,000 acres of bearing and non-bearing trees.[165]

The Mediterranean Subtropical climate favors the production of almond trees. The temperature requirements are very similar to those of the peach (See page 478.). The almond will tolerate intense heat during the summer, but it is very sensitive to low temperature in the spring.[166] Because the tree comes into bloom earlier than any deciduous fruit trees, the flower buds, flowers, and young fruits are easily subject to injury by spring frosts and cold. Therefore, almond orchards should be confined to lands that have good air drainage and are relatively free from spring frosts.[167] The best locations seem to be the banks of rivers, coastal hillslopes--in general, land slightly elevated above the floor of a valley or coastal plain.

The almond grows with less moisture requirement than most

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164 Op. cit., p. 380.

165 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 297.

166 Ibid., p. 297.

167 Ibid., p. 297.

fruits, and will grow in soils too dry for the peach. Therefore, irrigation is not a necessity; but if the orchards are irrigated in the autumn or spring, a more uniform cracking of the hulls to release the nuts in the fall will result.[168] The almond can stand very dry weather. In southern Spain and the Balearic Islands it replaces the olive and grape on the driest, sunniest slopes exposed to the full glare of the sun. This tree has drought-resistant characteristics--elaborate root systems, hair on leaf and fruit to retard evaporation--and so is able to thrive in a climatic region having hot, dry summers. As a result, this tree has special promise for arid lands. Wild, woolly fruited almonds, growing on the desolate shores of Pyramid Lake in the Nevada Desert, bearing nutritious though small and bitter nuts, range from northern Mexico to southern Oregon, surviving desert conditions where the rainfall in some seasons is not more than one inch a year. The desert may yet bloom with varieties of wild almonds brought from Central Asia which produce a good fruit and edible oil in a climate with an estimated rainfall of eight inches a year.[169]

The almond requires light or sandy, well-drained soils.[170] In Syria and North Africa almonds are grown on dry, stony soils. In California good paying crops are secured only on fertile,

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168 Op. cit., p. 298.

169 Ibid., p. 233.

170 Ibid., p. 234.

well-drained soils, preferably warm loams.

Propagation of almonds is mainly by budding on seedling bitter almond stock in nursery beds. After a year's growth in the nursery, they are planted in orchards. Here the tree is shaped in the first three years' growth after which little pruning is required. Light irrigation in the autumn and spring insures better fruit setting, and a more uniform cracking of the hulls in releasing the nuts in the fall. Two to four years after budding the first nuts appear, though commercial bearing does not begin until from the fifth to seventh years. Maximum fruiting is reached from the seventh to tenth years. In California 200 to 500 pounds of almonds per acre is an average yield.

The harvesting season in California is from August to October. The nuts are ready for gathering after they have dropped to the ground,[171] or when the hulls in the center of the trees start to split. In some regions the nuts are knocked off by striking the smaller branches with long poles,[172] or by jarring the nuts off by striking the larger limbs with rubber hammers. Then large sheets of canvas are spread under the tree to catch the falling almonds and facilitate the gathering.

If shelling is desired, it is done either by machines

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171 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 302.

172 Ibid., p. 302.

which crack and suck away the shells through air ducts, or by hand. Imported almonds are marketed shelled, while American-grown ones are always in the shell. The nuts are then dried or cured in special sheds or driers. When the kernels are dried, so that they will be crisp, they are graded for quality and sacked, and kept a number of months in a cool, dry place until ready for shipment. Since brightly and uniformly colored almonds are in demand by trade, they are bleached by subjecting them to fumes of sulfuric acid or by immersing in a bleaching solution of chlorine.

The United States obtains most of its sweet almond supply from the Californian groves and some from the Mediterranean countries. Bitter almonds are imported from southern Europe, being limited in their production chiefly to that region. The total imports of both kinds of almonds into the United States in 1935 was listed as 10,887,603 pounds.[173] The Mediterranean countries furnish the almond supply for the countries of northwestern Europe.

Sweet almonds are sold candied, salted, or made into almond meal, paste, or oil and emulsion for use internally in medicine.[174] Bitter almonds serve primarily as a source of oil of almond which is used as a flavoring extract.[175]

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173 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 376.

174 Ibid., p. 373.

175 Ibid., p. 374.

The Chestnut. The chestnut might be appropriately named the "tree corn" since it serves as a standard article of food, as important as corn is with us, both as a food for animals and man. The chestnuts are the nut fruits of several varieties of Castanea or chestnut trees, the nuts being characteristically enclosed in burs. The sweet chestnut (Castanea vulgaris)[176] is the species whose nuts are of commercial importance in the southern countries of Europe, bordering the Mediterranean.

Probably originating near the Black Sea in Asia Minor,[177] the chestnut has spread westward along the Mediterranean Sea and northward into the heart of Europe. Other claims are that it is native to the temperate climates of Asia, Mediterranean Europe, and eastern United States.[178] The chestnut assumes the greatest importance in regions of the Mediterranean Subtropical climate. In Europe the chestnut groves (Castanea vulgaris) cover astonishingly large areas on rough slopes of the southern coast from the Caspian Sea to Portugal.[179] Particular areas involved include the steep and rocky slopes in many parts of Spain, central France, Corsica, Italy, the Balkan countries, Al-

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176 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 353.

177 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 379.

178 Op. cit., p. 353.

179 Ibid., p. 353.

geria, and Tunisia.[180] The greatest quantity of chestnuts are grown in Italy which in 1920 produced 1,370,000,000 pounds. The best chestnuts come from Sardis in Asia Minor and from the neighborhood of Naples, Italy.[181]

In the eastern part of the United States, from Maine to southern Michigan and southward to Delaware, Tennessee, and Mississippi, the American species (Castanea dentata) formerly grew abundantly, but the ravages of the chestnut blight have almost wiped out the tree in the last twenty years. In China and Japan the Castanea crenata is much cultivated for its productiveness, its large nuts, and its freedom from blights, thus giving promise for grafting on American species.

The chestnut reaches greatest importance in countries in the Mediterranean Subtropical climate, though it also is cultivated in regions of temperate conditions, particularly those having the Humid Continental-Long Summer Phase. The chestnut thrives in regions of temperate conditions and where there is about 40 inches of rainfall a year. In the Mediterranean area the zone of chestnut orchards is usually from 1000 to 2000 feet above sea level, being planted at higher altitudes because near the sea at lower altitudes there is little summer rain.[182] The

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180 J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p. 107.

181 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 353.

182 Op. cit., p. 107.

tree thrives on rocky hillsides and even steep mountain slopes where the soil is untillable.

In the United States chestnuts are obtained by a type of collecting industry, the nuts being collected mainly from the natural forests. The product has suffered a decline since the invasion of the chestnut blight, and eventually will be of only minor importance in this country.[183] At present the growing of this nut is in a highly problematic stage, there being no inducement to plant them in orchards. A possibility exists in developing chestnut culture west of the Rockies where the blight does not seem to exist. In the southern Appalachians the people roam at will through the woods gathering chestnuts for shipment to cities of the northern and central parts of our country. In the Mediterranean countries it is more in the nature of an agricultural crop, being planted in groves and orchards.

The favorite way of propagating each of the Castanea species is by grafting upon "sprouts" developed from stumps where chestnut trees have been cut down. In Corsica, on steep mountain sides every tree is a grafted chestnut, and the crop makes the land worth $200 per acre.[184] Grafted chestnut trees on granitic hillsides in southern France places a value of $160

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183 Op. cit., p. 118.

184 J. Russell Smith, Commerce and Industry, Henry Holt and Company, 1925, p. 174.

per acre on the land.[185] To encourage heavy crops of nuts the trees are kept far enough apart for the light to fully reach the ends of all the branches, usually planted four to an acre. At the start trees may be set ten feet apart, each second tree to be removed when the branches begin to touch; a second thinning may be made when trees left the first time touch each other. In some places as mature trees reach old age, new trees are planted near the old trees, and in ten, fifteen, or twenty years when the old tree is removed, the young tree is developed, though up to this time its growth may have been stunted because of the presence of the old tree. While the trees are young, they should not be allowed to ripen all the fruits they set, as this might check their growth.

The chestnut first bears at the age of two or three years. Commercial bearing begins around five or ten years, and the tree yields an annual harvest of from 1000 to 2000 pounds of chestnuts per acre.

The harvesting season begins in September. A few weeks before the chestnuts ripen (in August or September) the orchards are scythed to remove things the goats and mules cannot eat. In September the chestnuts are harvested by children, men, women going through the orchards picking up the nuts which are loaded onto the backs of donkeys and mules and carried thus to

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185 Op. cit., p. 648.

to the village. After the nuts are gathered, the pigs are let loose to turn the leaves over and find the nuts which may have escaped the human eye.

Some nuts are shipped fresh to market while the main crop is dried up for local use. The nuts are spread upon the slatted floor of a stone dry-house. From a slow fire in the basement smoke and heat rise through the slatted floor to dry the nuts that have been spread upon it. This kills all the worms and cures the nuts so that they will keep as well as any grain. Its keeping quality allows it to be stored and so it has great promise as a forage crop. In Italy and France, after drying, the nuts are ground into a meal called chestnut flour.

Though much of the chestnut crop is used locally, some is exported. Large chestnuts from Italy are imported into the United States for stuffing; some candied chestnuts are imported from France.[186] In 1935 imports by the United States equalled 16,681,390 pounds.[187] Other exports from the Mediterranean countries go to the countries of northwestern Europe.[188]

Chestnuts serve as food for man as well as for animal. Chestnut flour or meal is used in making bread and cakes, form-

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186 Forrest Crissey, The Story of Foods, Rand McNally and Company, 1917, p. 465.

187 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 376.

188 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 379.

ing one of the principal articles of food of many people in Italy, France, Corsica, and Spain. In Japan the chestnut is an important food supply taking the place of the potato in some of the mountain regions. Chestnut is largely a forage crop for goats and cows, and a corn substitute for pigs.

The great chestnut need of America is for a forage nut to enable Appalachian mountaineers and owners of hill lands almost anywhere to abolish their corn fields by growing a "tree corn" for their pigs and cows.

The Filbert. These nuts are in considerable demand at holiday times, but otherwise do not make important contribution to trade. A large European species, Corylus avellana,--native to the temperate parts of Europe--is the source of the filbert, a nut fruit which grows in clusters of from one to three.

At present filberts are cultivated to a considerable extent in the Mediterranean countries of Europe and the Caucasus region of western Asia. Best European varieties come from Spain. At present commercial culture of filberts is confined almost exclusively to the valleys of our Pacific Northwest--Oregon and Washington--and more recently in certain parts of California.[189]

The climatic requirements of the filbert cause it to do best in areas having the Mediterranean Subtropical and the

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189 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 299.

the Marine West-Coast climate. Very early blooming limits their growth to these sections which have mild, moist winters. The trees thrive on a variety of soils. A well-drained fertile soil of light texture and at least four feet in depth is satisfactory.[190] For good yields the soils must be maintained in high fertility.

In our northwestern orchards layering is the most satisfactory method of propagation. The propagated plants may be transplanted to nursery beds to develop into trees. After orchards have been set out with young trees, certain care is required. The filbert trees must be headed low and trained by proper pruning to form five to six main branches. Thereafter, regular pruning is necessary in order to encourage a continuous formation of new growth, for the nuts are borne on one-year old wood.[191] Regular cultivation of the ground in the orchard, growth of cover crops, and irrigation where necessary are all part of the care needed by filbert orchards.

Filberts come into bearing early, crop regularly; and the gathering, handling, and marketing of the nuts is a simple procedure. By the fifth or sixth year the trees begin to bear a profitable crop of nuts,[192] and continue to bear annually for many years. The crop is harvested by gathering or picking the

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190 Op. cit., p. 299.

191 Ibid., p. 299.

192 Ibid., p. 300.

nuts from the ground after they have dropped from the tree naturally.[193] Several pickings occur during the harvest season, for if the nuts are left on the ground too long, they may become discolored. They are then dried or cured either in the sun or in special sheds or dryers, with or without artificial heat. Then the filberts are packed and sold in sacks or bags of various sizes and marketed through cooperative organizations.

Most of the filberts are consumed in the United States or in the countries of northwestern Europe. Though filberts are produced in the United States, imports of 5,637,614 pounds of shelled and unshelled filberts were recorded for 1935,[194] coming mainly from the Mediterranean countries.

The Persian or English Walnut. Although many kinds of walnuts are grown, the commercial culture of the Persian or English walnut (Juglans regia) is the only group of importance. It is the food nut most widely used in the United States at present. In spite of its name this nut is a native of Persia from whence it spread both westward and eastward.[195]

The Persian or English walnut is most extensively cultivated in the North Temperate regions of the Mediterranean Subtrop-

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193 Op. cit., p. 302.

194 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 376.

195 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 427.

ical type of climate.[196] In southern Europe the trees are grown in the mountain valleys, particularly those which are seaward-facing valleys, in France, Italy, Portugal, Spain, and the Balkan states. In western Asia they flourish to good advantage in the coastal valleys of Palestine and Syria; in Asia Minor they are cultivated where irrigation is possible. Parts of eastern Asia, particularly south and west of Peking, is another center of walnut production.

Commercial culture of this nut tree in the United States is confined as yet to the Pacific Coast where the Mediterranean Subtropical conditions of climate prevail, though its extension northward into the Marine West-Coast climate is being attempted.[197] California supplies 90 per cent of the marketable crop of the United States.[198] The most important region of production is south of Santa Barbara, centering around Los Angeles.[199] The central California walnut region, bordering San Francisco Bay, is of lesser importance. Northward from California, walnut production has been developed in comparatively recent years in the Willamette Valley of Oregon and in Clark County of Wash-

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196 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 379.

197 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 289.

198 Ibid., p. 290.

199 Ibid., p. 290.

ington, near Seattle.[200] Here the orchards are still in the stage of adjustment; and despite some serious damage by winter killing the industry in Oregon and Washington has been so far fairly prospercus.

The Persian or English walnut trees are exacting as to climatic requirements, being most successfully grown where there is a comparatively long growing season free from frosts. They are easily injured by frost in the spring and fall and by excessive heat in the summer.[201] In addition, the tree cannot stand sudden changes in temperature. Like the filbert and almond, the walnut seems best adapted to regions having a relatively dry growing season with only moderate summer temperatures.[202] Most favorable conditions, therefore, are to be found in the coastal districts or seaward-facing valleys, as in California and the Mediterranean belt of southern Europe. Because of the greater liability of winter killing, sites for walnut orchards must be very carefully selected in Oregon and Washington; therefore, slight elevation above the floor of the valley, giving good air drainage, is preferred for such sites.[203]

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200 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 290.

201 Ibid., p. 289.

202 Climate and Man, Yearbook of Agriculture, U. S. Department of Agriculture, 1941, p. 417.

203 Op. cit., p. 291.

Deep, well-drained soil is a prerequisite for the profitable growth of these trees.[204] If the soil is shallow and underlaid with hardpan, trees grow slowly, become stunted, and will yield poor crops. A fairly heavy loam of six to seven feet in depth, well-drained, is recommended for walnut development.

The Persian or English walnut trees require an abundance of moisture and plant food.[205] Walnut orchards in southern California are irrigated at least two to four times a year, while elsewhere water is conserved by proper cultivation.[206] While rainfall in winter is subnormal, a heavy winter irrigation is necessary to supply ample moisture for spring growth, usually followed by additional applications of water in June, July, and August. Light soils must be irrigated more often than the heavier types.

In the Old World scattered walnut trees are found along roadsides and field sides.[207] In France some farmers plant these trees about their fields at irregular intervals and then go on with their farming within the enclosed field. Often these trees are rented, one good walnut tree bringing in the

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204 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 291.

205 Ibid., p. 292.

206 Ibid., p. 293.

207 J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p. 166.

same rental as from an acre of plowed land.[208] In the drier sections of Europe and western Asia these walnut trees are a part of two-story agriculture; especially is this so on the slopes of Vesuvius and nearby Sorrento Peninsula.[209]

In the United States production of this walnut is a cultivated orchard industry. The present practice in setting out orchards is to secure well-developed trees of desirable variety from nurseries. Orchards are set out with trees in late fall or early winter when the Mediterranean conditions of winter rainfall and cool winter temperatures give root systems an opportunity to regenerate and become established before growth in spring begins.[210] Ordinary orchard care is required: pruning to maintain yields; spring plowing and cultivation at intervals thereafter; planting of cover crops; fall plowing to catch and hold winter rains.

Orchard trees bear walnuts in four to six years, though commercial bearing begins from six to ten years and lasts for thirty-five to forty years. Nuts are produced annually. The average yield per tree is about fifty pounds; in California the yield per acre is from 300 to 450 pounds.[211]

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208 Op. cit., p. 167.

209 Ibid., p. 169.

210 Ibid., p. 292.

211 J. Russell Smith, Men and Resources, Harcourt, Brace and Company, 1939, p. 134.

When ripe, the hulls separate and the nuts drop to the ground, from which they are gathered. The walnuts are then cleaned in special washers, then dried or cured in the sun or special sheds or dryers, with or without artificial heat. Nuts not dried become moldy and acquire an unpleasant taste. In community or cooperative packing houses further steps are attended to: bleaching to give uniformly colored walnuts; sizing; grading,--according to size, freedom from external blemishes, and quality of the kernel.

Large exporters of Persian or English walnuts include France, Italy, and China which send these nuts principally to the United States and countries of northwestern Europe.[212] Nuts not exported in the eastern Mediterranean region are used to fatten turkeys. In addition to these uses walnuts yield an excellent oil for table use and the oil cake is a good stock feed. Walnut oil, made from mature and old kernels of this walnut, yields a drying oil used for white paint and artists' oil paints, for printing ink, and soap.

Imports of walnuts in the year 1935 amounted to 5,566,609 pounds.[213]

The Pistachio Nut. The pistachio or green almond is a

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212 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1935, p. 380.

213 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 376.

small bean-shaped nut of green color and peculiar flavor produced on a small tree (Pistacia vera)[214] which is a native of Syria and Persia. The pistachio nut of commerce is the seed of the dry drupe, the fruit of this tree.

The pistachio-nut tree is now cultivated widely in the dry areas on the borders of the tropics and the subtropics, where the summers are hot and dry and the winters moist and mild, in such places as have the Mediterranean Subtropical climate.[215] The tree is widely grown in the Mediterranean countries, particularly in Sicily, Italy, France, Greece, Syria, Palestine, Algeria, and Libya.[216] In southern Turkey the nut is gathered from wild trees.[217] Some of the most extensive plantations are found in Afghanistan, Persia, Syria, and Palestine.[218] Pistachio growing is a cultivated orchard industry in the United States with established groves in southern California and Florida.

Pistachio has a wide climatic range, but is particularly at home in the Mediterranean climate. It will grow at altitudes

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214 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 516.

215 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 379.

216 J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p. 229.

217 Ibid., p. 223.

218 Op. cit., p. 379.

up to 5000 feet. It is not particular in its soil requirements, thriving in rocky places that are almost devoid of soil. It has been found clinging in crevices of rock where there is almost no soil.[219] Where the soils are thin, especially on that underlaid by limestone, the pistachio is able to thrive. Therefore, steep, rocky slopes within the Mediterranean regions can be made useful with established orchards of pistachio.

The nuts are gathered from wild trees as well as from those cultivated in orchards or plantations. Those trees grown on a commercial scale are propagated by grafting and budding. It takes fifteen years before pistachio trees bear fruit.[220] Then the tree is irregular in its bearing habits, fruiting once in five, six, or seven years, with rarely a heavy crop.[221] In years of good yield from six to twelve bushels of nuts (150 to 300 pounds) per acre may be obtained.[222] In view of the fact that the trees are male and female, it is perhaps possible that more regular and dependable crops could be obtained if the planters were to provide pollen-bearing insects to fertilize the trees; but this is a problem that has yet to be solved.

After the nuts have been gathered, they are boiled in salt

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219 J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p. 229.

220 Ibid., p. 231.

221 Ibid., p. 230.

222 Ibid., p. 230.

water until the shells crack. Both shelled and unshelled pistachios are imported into the United States, amounting in 1935 to 3,091,079 pounds.[223] They are highly prized for their color and flavor, and are utilized principally in mixed nuts, for flavoring, for oil, for coloring and flavoring ice cream and confectionery.

MISCELLANEOUS

Cork. Cork is one of the oldest and most valuable of the forest products. It is obtained commercially, for the most part, from the outer bark of two species of cork oak (Quercus suber and Quercus occidentalis),[224] a native of the western Mediterranean region of southern Europe and northern Africa, between 34° and 45° latitude, North.[225]

The cork of commerce today is limited in its production to the Mediterranean region, to the belt extending from the Atlantic Ocean to Asia Minor, being practically confined, however, to the western end of the belt.[226] The Iberian Peninsula alone, involving Portugal and Spain, is the world's center of cork[227]

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223 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 376.

224 Cork: Its Origin and Uses, Armstrong Cork Company, 1930, p. 6.

225 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 433.

226 Clarence F. Jones, Economic Geography, Henry Holt and Company, 1935, p. 250.

227 Op. cit., p. 433.

production, supplying nearly two-thirds the world's cork. Algeria, with Tunisia, ranks next, followed by France, Morocco, and Corsica.[228] To a limited extent it is produced in Greece, Italy, the Dalmatian Coast, Tripoli, and Asia Minor.[229] In all these regions a total of about 4,000,000 acres are in cork forests,[230] and over 500,000,000 pounds of cork are produced annually.[231]

The cork forests of Portugal and Spain are the richest and most productive. Portugal probably produces more cork than any of the above-named countries, but Spain is regarded as the center of the cork industry because it imports large quantities from Portugal and re-exports it together with the Spanish product in the various manufactured forms.[232] From the Tagus Valley of Portugal southward is the major area of Portugal's cork supply.[233] In Spain alone the area of cork amounts to about 750,000 acres, occurring largely in the province of Estremadura

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228 Cork: Its Origin and Uses, Armstrong Cork Company, 1930, p. 6.

229 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 433.

230 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 95.

231 William O. Blanchard, The Cork Oak, Journal of Geography, XXV (1926), p. 245.

232 Ibid., p. 248.

233 Ibid., p. 247.

in the southwest where the Guadiana River flows southward, in Catalonia in the northeast, and in Andalusia.[234]

The cork oak thrives best on the granitic land and sandy soils upon the hillsides and lower mountain slopes,[235] on almost barren soil which is unsuited to agriculture. The product of those trees grown on shallow stony soils is thinner but of better quality than that grown on deep fertile soils. Where the cork is grown on rich soils in the lowlands, it is thicker, more spongy, and of less value.[236] This suitability of the cork oak to poor rough land makes the establishment of plantations difficult.[237]

The tree will grow under very dry conditions. It is a drought-resistant tree with drought-resistant features. The thick leaves and thick bark prevent evaporation. A branching root system assists in obtaining the needed moisture from over a broad surface.[238] The tree has the ability to thrive in the heat and humidity of the American Cotton Belt (Georgia, Flori-

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234 Op. cit., p. 244.

235 Ibid., p. 245.

236 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 435.

237 Clarence F. Jones, Economic Geography, Henry Holt and Company, 1935, p. 250.

238 Cork: Its Origin and Uses, Armstrong Cork Company, 1930, p. 6.

da, and Louisiana) as well as in the dry summer climate of California. Trees planted there in 1880 to 1890 are still living, but are not worked for commercial cork which under proper management would probably yield.

A combination of climatic and environmental conditions which result in slow growth is needed for the production of a cork of superior quality and fine texture.

Experienced, skilled workmen are needed in the cork industry. They must decide for each tree how high the bark should be removed. The stripping and removal of the bark requires skill, for if the inner bark is injured at any point, it becomes scarred and successive removals of bark are rendered much more difficult.[239]

Cork production requires freedom from hot, drying winds during stripping time. Whenever the Sirocco--a hot storm from the Mediterranean--is raging, the cork is never stripped[240] as the wind would cause undue drying of the tender inner bark exposed after stripping.

Transportation presents a problem in the cork industry. Most of the cork forests are in the mountains or other almost inaccessible positions where roads are undeveloped.[241] There-

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239 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 437.

240 Cork: Its Origin and Uses, Armstrong Cork Company, 1930, p. 7.

241 Ibid., p. 10.

fore, trains of burros are used for transportation because of the lack of roads.

The cork grows without cultivation in some of the poorest sections of the western Mediterranean region. Once a cork grove is established, however, it produces for a long time, 150 years or longer. Little care beyond occasional cutting of undergrowth and thinning is involved with the growth of the cork oak; thus, cork, though a good crop for poor land, is hard to establish in plantations. The tree is usually twenty years old before it gives its first stripping of cork.[242] Commercial stripping occurs between twenty and thirty years after planting of the tree, which must, according to Portuguese and Spanish law, be at least five inches in diameter before stripping may be done.[243] The first stripping of cork is called "virgin" cork and is of little value, being of inferior grade.[244] The third stripping produces good cork. Stripping occurs only once every eight to ten years,[245] according to the locality, with the best bark obtained when the tree is around forty years of age. The average productive span of a cork oak is from 100 to 150 years, though trees commonly attain an age from 100 to 500 years or more. Some growers in Spain estimated that cork is

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242 Op. cit., p. 7.

243 Ibid., p. 7.

244 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 437.

245 William O. Blanchard, The Cork Oak, Journal of Geography, XXV (1926), p. 242.

being produced from trees up to 300 and 500 years of age.[246] More than a ton of cork is produced from an acre containing a full stand of seventy trees. The amount a tree produces varies from 45 to 1500 pounds of cork per tree.[247] One tree in Estremadura (Spain) is reported to have yielded 3960 pounds in a single season.[248]

The time of stripping varies in different parts of the Mediterranean region, but is best when the sap is running freely--from June to early September.[249] The most opportune time to strip is during hot weather following a good rainfall. The procedure consists of cutting a ring completely around the top and bottom of the trunk of the tree; then a vertical cut is made up the trunk and as many horizontal rings around the tree as seem necessary, extreme care being taken not to injure the inner bark. After this, the bark is carefully pried off.

After the strips and slabs have been removed from the trees, they are piled up at a convenient point in the forest and allowed to dry for several days. Then they are weighed and shipped to some central point for boiling to remove the sap and

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246 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 436.

247 C. Langdon White and George T. Renner, Geography: An Introduction to Human Ecology, D. Appleton-Century Company, 1936, p. 113.

248 William O. Blanchard, The Cork Oak, Journal of Geography, XXV (1926), p. 242.

249 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 437.

tannic acid. This increases the volume and elasticity, and flattens the pieces. It also loosens the outermost layer, which is scraped off.

Commercial uses depend on certain physical characteristics of cork. More than half the cork, usually the waste from cutting bottle stoppers, goes into refrigerators and cold storage plants as insulation, for cork does not conduct heat easily. For the same reason it finds uses as hot plate mats, helmets for hot, sunny climates, and cigarette tips. As it is light in weight and buoyant, it is most useful in life preservers, life belts, floats, and buoys. It is compressible and impervious to liquids and therefore excellent for bottle stoppers. Other uses are for linoleums (made from cork flour which is cork waste), linings for hats and soles for shoes, stuffing for boat cushions, washers, gaskets, fishing rods, bicycles, and cork paper.

The United States imports about a million pounds of cork annually, and Germany, Great Britain, and Russia (in normal times) are also large consumers,[250] the cork being imported from the Mediterranean countries, mainly from Spain. The annual exports from Spain sometimes reach a value of thirty million dollars.[251]

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250 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 95.

251 Samuel Van Valkenburg and Ellsworth Huntington, Europe, John Wiley and Sons, Inc., 1935, p. 385.

The cork industry is being faced with competition from a new product made from peanut hulls and which is serving as a substitute for cork, being nearly as efficient for soundproofing and insulation as cork is, and 35 per cent cheaper.

CHAPTER XIII

TREE CROPS COMMON TO THE HUMID AND MEDITERRANEAN SUBTROPICAL CLIMATES

Regions of Humid and Mediterranean Subtropical climates differ climatically in the amount and distribution of rainfall. The former type of climate has a rainfall of 35 to 60 inches, distributed quite evenly during the year; the latter has an annual rainfall of 10 to 30 inches, which comes mostly during the low-sun period. Some regions within the Mediterranean type can compensate for their lack of summer rainfall by means of irrigation, and so are able to produce certain tree crops--especially fruits--similar to those grown in the Humid Subtropical areas. Such tree crops have been combined in this chapter; all of them produce fruits which are edible--for man and beast; the mulberry, in addition, produces leaves which form the basis for sericulture in some localities.

The Fig. The fig tree (Ficus carica)[1] has been cultivated since earliest time. It appears to have originated in the middle and southern parts of the Mediterranean Basin, from Syria to the Canaries.[2] Today the fig is widely grown in the

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1 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 295.

2 Ibid., p. 298.

tropics and subtropics, the principal centers of commercial production being the Mediterranean countries, southern California, and southeastern Texas.

Two types of figs are raised: the Smyrna fig, which is mainly dried for market and is grown in regions of the Mediterranean Subtropical climate; and the Magnolia fig, which is preserved in thick syrup and is grown in regions of the Humid Subtropical climate.[3]

The important Mediterranean countries which raise figs include Spain, Portugal, the hill country of northeastern Algeria, Italy, Greece, Palestine, and Turkey. In the last named country the fig is found along the coast and in the valleys around Smyrna. Turkey leads all countries in the production of this fruit.

Within the United States southern California is the leading section of production. The region around Fresno in the San Joaquin Valley produces about one-third the figs consumed in the United States.[4] Figs are also produced around Houston in southeastern Texas; nearly all the figs grown here are canned. Louisiana has also established fig orchards.

Figs are also grown in the southern part of Africa, the

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[3] Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 373.

[4] Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 267.

Central Valley of Chile, and the southwestern part of Australia.[5]

The climatic requirements of figs differ according to the variety. Varieties grown for table use do not need as warm temperatures as do those grown for drying. Both varieties of figs require freedom from long continuous winter cold. When the fruit is ripening, warm nights are desirable; cold nights even with warm days cause the fruits to be dry, hard, and deficient in sugar. Too high temperatures (those over 100° F. in the shade) are apt to bleach and harden the skin of the fig during the ripening season.

Natural rainfall of not less than 25 inches which falls from November to May with none during the summer is desirable. When the fruit is ripening, a dry, warm season, especially at night as well as during the day, is best. A shower of rain on mature or nearly mature figs is detrimental, causing them to break open, turn sour, and become undesirable. Where the yearly rainfall is under 25 inches--as in California--irrigation must be practiced. Fogs are injurious for they prevent the proper development of sugar, and injure the color of the skin. For this reason figs are kept away from the coastal areas of California.

Warm, deep, well-drained loam soils, rich in plant food and

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5 Op. cit., p. 267.

especially lime, are most satisfactory. Sandy soils, if sufficiently rich and retentive of moisture, are satisfactory and produce sweet figs of light color when dried.

Figs are propagated either from cuttings or by layering. The latter shoots when rooted will form plants ready to bear the first or second year after planting and so is preferred as the method of propagation. The fig is an early bearer. Some bear but one crop a year; others, two crops a year, one in early summer and one in autumn; some have three and even continuous crops throughout the year.

The Smyrna fig is the outstanding commercial fig because of its flavor.[6] It depends on fertilization by the fig wasp (Blastophaga grossorum), an insect which spends part of its life cycle in the fruit of a wild variety known as the Capri fig.[7] The wasp emerges from the wild or Capri fig and enters the opening in the end of the Smyrna fig, carrying upon itself a portion of Capri fig pollen which thus fertilizes the Smyrna fig, causing normal development of seed, flavor, and aroma. Thus there is the necessity of planting at least one Capri fig tree for every 100 Smyrna as well as the need of a supply of fig wasps to accomplish the caprification. Often twigs of the wild tree are clipped and hung on the Smyrna fig trees. The

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6 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 485.

7 Ibid., p. 485.

development of fig growing in the United States was retarded until the habits of the fig tree were understood; both the wild trees (Capri fig) and the fig wasps had to be brought from Asia Minor and it took time to acclimate the wasp.[8] Only the Smyrna fig requires caprification, while the Magnolia does not require wasp fertilization.[9]

In the northern hemisphere the figs usually ripen about the first of August. The method of harvesting depends upon the use of the fig. For drying (Smyrna figs) the figs are picked up as they fall to the ground. As they mature, they shrivel so that after picking from the ground they are dipped into boiling brine and then placed on trays in the sun, those of better quality being much pulled and extended by hand during the process. The figs are turned over once, and then allowed to finish in the shade. Then they are placed in sweat boxes so that the moisture will equalize. Later they are washed again clean in a weak brine and packed closely for commerce.

For eating fresh and canning the fruit must be allowed to fully ripen and should be picked just before it begins to soften. Harvesting is usually done early in the morning.

Though fresh figs are a favorite fruit in the producing

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9 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 373.

8 Op. cit., p. 485.

districts, the trade deals chiefly in the preserved or dried forms. The Mediterranean lands--particularly Turkey, Greece, Italy, Spain, and Algeria--are important exporters,[10] shipping figs mainly to Great Britain and the United States. Though the United States in 1935 produced 35,590 tons of figs in California and Texas,[11] it also imported considerable quantities, chiefly from Turkey and Greece.[12]

The Grapefruit. The grapefruit or pomelo (Citrus decumana)[13] is the largest of the edible citrus fruits, and is a favorite on many American breakfast tables. The pale-yellow fruits are frequently borne in grape-like clusters just as grapes hang from vines. They vary in weight and size, from two pounds to twelve pounds, with diameters of four to six inches. The flesh is acid or subacid, and mildly bitter.

This important fruit has a doubtful origin. It is thought to be native of South China and the East Indies (Malaysia and Polynesia).[14] Now the trees are extensively grown in most tropical countries and have recently been extended into the sub-

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10 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 485.

11 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 447.

12 Ibid., p. 447.

13 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 177.

14 Ibid., p. 177-178.

tropical parts of the world.

The United States is an important producer of grapefruit, there being 13,000,000 grapefruit trees here in 1935.[15] The peninsula of Florida is the world's foremost center of grapefruit production, producing between 1925 and 1930 about 90 per cent of the world's supply.[16] In this state grapefruit is raised in the flat lowlands, in the eastern and western coast regions, and also on the rolling central upland. In the latter region the rolling condition of the land affords protection against cold waves which often sweep in from the northwest; some local protection is afforded by planting on sloping land where air drainage is effective, and numerous lakes add to their protection at critical times.[17] In Florida the summer rainfall makes irrigation unnecessary, and the high humidity develops a fruit of high juice and lower solid content.[18] The great swamps of southern Florida keep grapefruit culture out of that region. Florida has the advantage of being much closer to the great eastern markets to which the fruit moves quickly.

Though grapefruit can be raised in the valleys of southern

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15 J. Russell Smith and M. Ogden Phillips, North America, Harcourt, Brace and Company, 1940, p. 351.

16 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 514.

17 Ray H. Whitbeck and Vernon C. Finch, Economic Geography: A Regional Survey, McGraw-Hill Book Company, Inc., 1941, p. 100.

18 Ibid., p. 100.

and central California, that state has the disadvantage in competing with Florida in the eastern markets, on account of the greater expense of rail transportation, and the time of year at which the crop matures--summer. This comes after the Florida fruits have been on the markets and so are not ready to fulfill a great demand.

The lower Rio Grande Valley in Texas produces 20 per cent of our grapefruit crop.[19] The orchards are situated far south on the irrigated delta of the Rio Grande, out of reach of most of the cold winds that make citrus fruits a minor feature of the agriculture on the Gulf Coast between there and central Florida.[20] This region competes with Florida and California, being rival with California for second place in grapefruit production.

Other minor areas of production in the United States include the Mississippi Delta of Louisiana, southern Alabama, the warmer parts of New Mexico, and the Salt River Valley in Arizona.[21]

Four of the West Indian islands--Jamaica, Cuba, Porto Rico, and Santo Domingo--raise grapefruit for commercial purposes. Jamaica is the most important producer of the four, while Cuba

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19 Op. cit., p. 100.

20 Ibid., p. 100.

21 J. Russell Smith and M. Ogden Phillips, North America, Harcourt, Brace and Company, 1940, p. 593.

is noted for the excellent quality of its grapefruit. In these islands fruit losses from hurricane damage is a problem facing all orchardists.

Grapefruit are among the chief agricultural exports of Trinidad.[22] To the south, in South America, in Caribbean Colombia and also in Brazil grapefruit is being raised as a subsistence crop on coffee plantations.[23]

Expansion of grapefruit culture is reported in Palestine, South Africa, southern China, and India.

Florida and Texas will probably remain the principal centers of production because of the abundance of suitable land, sufficient rainfall, and less danger of hurricanes than in the West Indies.

The grapefruit is common in regions of both the Humid Subtropical and Mediterranean Subtropical climates. This fruit requires tropical and subtropical conditions of temperature and rainfall. While the trees are young, they are tender to frost, but as they become fully clothed with foliage, they outgrow this weakness to a large extent.

A well-drained, sandy loam soil is favored by the grapefruit. Liberal fertilization of soil is required in order to produce good crops.

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22 Op. cit., p. 870.

23 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 571.

The grapefruit is propagated by budding on sweet orange, sour orange, rough lemon, and grapefruit stock. Bearing begins at three to four years of age with full bearing being reached in about ten years. Fruit is borne annually for fifty years or more.

The time of harvesting differs with the region of production. In Florida the grapefruit is a winter and spring fruit, while in California the greatest harvest is in summer. Picking should be for size; in the fall and early winter the demand is for large sizes, while toward the end of the season conditions are reversed. Then the larger sizes are at a discount, many buyers preferring medium and small fruits. Grapefruit are not left on the tree to ripen because the seeds are apt to sprout and the fruits lose flavor. Fruits must always be cut off with a knife or preferably, clipped with round-ended shears. These precautions are taken so that the skin will not be broken or accidently pricked. Scratches on the fruit must be avoided because decay organisms might thus enter and destroy the fruit; so to avoid this, pickers wear cotton goves during harvesting.

The fruits are graded, wrapped, and packed for shipment to market after "curing" for four to five days to get rid of their excess moisture and thus shrink, becoming the tougher and thinner so they may be handled and packed with little or no risk of damage.

The United States imports grapefruit from Porto Rico in

addition to supplies received from its southern states, particularly Florida. California exports quantities of grapefruit to the Orient in normal times. In 1935 the United States produced 17,945,000 boxes of this fruit: Florida, 10,500,000 boxes; California, 2,275,000 boxes; and the remainder from Texas and Arizona.[24] In 1934-5 the pack in Florida alone amounted to 3,588,042 cases of "hearts" and 2,236,726 cases of juice.[25] Porto Rico, in addition to Florida, cans considerable grapefruit--"hearts" and juice. Grapefruit peel is candied and used in marmalade. Sometimes the rind and seeds, obtained as a by-product in the canning of the fruit, are dried and ground for a fair grade of cattle feed.

The Lemon. The lemon (Citrus limonum)[26]--a small, light yellow, oval fruit with a blunt point at one end--is a popular citrus fruit, and is believed to be the first of the citrus fruits introduced into Europe. It is indigenous to the warm valleys at the foot of the Himalayas in northwestern India,[27] particularly Kumaon and Sikkim. From there, as early as the second century A. D., it was introduced into Mesopotamia, Pal-

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24 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 435.

25 Ibid., p. 435.

26 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 179.

27 Ibid., p. 179.

estine, and thence by the Arabs into southern Europe, where it has always been particularly adapted.

Though the lemon is of tropical origin, it reaches such commercial importance on the cooler margins of its habitat that we think of it as primarily subtropical. Lemons are now grown in all continents. Because this fruit is not hardy, it is grown commercially only in the warmer parts of those regions with the Mediterranean climate. The world's great commercial production is centered in the Mediterranean area, particularly in southern Italy and Sicily.[28] Italy is the world's principal lemon producer, 90 per cent of Italy's lemons being produced in Sicily.[29] Other portions of the Mediterranean area producing smaller amounts of this fruit include the coastal regions and valleys of Spain, France, Greece, Libya, Egypt, Turkey, and Portugal. The United States holds second place in lemon production, with 95 per cent of the American lemons being grown in the foothills of the west side of the Coast Ranges in Los Angeles County of southern California.[30] Smaller amounts are grown in the Rio Grande Valley of Texas and also in the southern part of Florida. In Florida, the danger from frequent frosts has caused the trees to be of less commercial importance.

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28 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice Hall, Inc., 1935, p. 493.

29 Ibid., p. 493.

30 Ibid., p. 493.

Smaller amounts are produced in the other Mediterranean countries, and in the Central Valley of Chile, South Africa, southwestern Australia, and New Zealand, but in none of them on an export basis.[31] The West Indies also grow some of this fruit.

The climatic requirements of lemons are more restrictive than for orange. A mild climate (subtropical) with much sunshine without freezing temperatures is a limiting condition to its growth. The lemon has less ability to withstand frost than other citrus fruits[32] (except limes). The need for freedom from frost places lemon production close to the coast in the Mediterranean areas. In those places where there is danger of frosts, oil-burning heaters are placed throughout the grove; or where possible, a liberal supply of water is run into the irrigation ditches. Such operations involve care and costs, but the results have justified them. Where warm winters with dry air conditions prevail, the lemons are solid, disease-free, and of good keeping quality.

Lemons do better where there is not much summer rainfall because too much at that season of year causes a prevalence of fungoid diseases. Where the summers are too dry, lemons are grown largely under irrigation to supplement the natural rain-

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31 Op. cit., p. 493.

32 Samuel Fraser, American Fruits, Orange Judd Publishing Company, 1924, p. 654.

fall. A depth of twelve inches of water a year is pumped into lemon groves in the drier parts of the Mediterranean Subtropical climate. Lemons require watering once a month for six months each year.

This fruit tree is adapted to a wide range of soils, but prefers a medium, well-drained loam. Heavy and poorly drained areas should be avoided. Where soil is poorly adapted to lemons but climatic conditions are favorable, the soil must be carefully mulched, fertilized, and managed to yield profitable returns.

After frost, the most feared danger is fungus diseases which have caused serious losses to lemon growers, especially in Italy. Ample light and air to all parts of the tree can do much to alleviate this danger. This has been accomplished by spacing the trees far enough apart to avoid overcrowding, scientific pruning, and methodical spraying.

Lemon orchards are usually planted with two year old seedlings grown from the bud on the sour orange as stock, or from cuttings. Four years after the orchard has been set out the trees bear their first fruits. Commercial bearing, however, occurs from eight to ten years after grafting or budding. The tree bears annually. The yield varies with the age of the tree. In general, an acre of fifty trees averages 73 packed boxes during the first nine years of production; during the seventh to ninth years an acre averages 227 packed boxes. Some indi-

vidual trees bear as much as 3000 fruits in a single year.

Lemon harvesting goes on at all seasons, the fruit being gathered once a month. Most of the harvesting occurs during the winter and spring months, however, since the lemon naturally ripens then. This harvested crop helps to fulfill the demand for lemons which is greater in summer than in winter.

For commercial purposes lemons are harvested while still green, since those fruits which are allowed to mature on the tree do not keep well. The fruit is clipped or cut, but not pulled. Only those lemons which have attained the standard size of 2¼ inches in diameter are gathered. A ring 2¼ inches in diameter carried on the finger of the gatherer is slipped over the lemon and those through which the ring cannot pass are harvested. In the United States much of the harvesting is performed by association men rather than by the growers.

Curing follows harvesting. Its purpose is to cause the skin to become thin, tough, and pliable by the slow ripening (30 to 60 days) and loss of moisture. Such fruits keep and ship well and contain more juice.

After curing, the fruit is washed, graded, wrapped in tissue, and packed for shipment--some of the work being done by hand, and some by machine.

The United States obtains its lemon supply largely from California and Sicily, while northwestern Europe is supplied by the Mediterranean countries of southern Europe.

The lemon finds use both as a food and drink. The rind is the source of oil of lemon, and the expression of the oil is an important industry in Sicily. It takes 800 to 1100 lemons to yield one pound of oil. Lemon oil is used in perfumery, soap, and lemon extract which is next to vanilla in importance as a flavoring substitute. Some lemon oil is also extracted from the seed. Citric acid from the oil in the rind is employed in dyeing and calico printing.

The Loquat. The loquat is the fruit of a small evergreen tree (Eriobotrya japonica).[33] The fruit resembles the plum in appearance, being pear-shaped and having a pale yellow to orange-colored skin which is thin, smooth, and somewhat tougher than that of the apple. The flesh is white to salmon color, juicy, and of a flavor suggestive of cherry; it is slightly acid and not so sweet and rich as most tropical fruits.

Eriobotrya japonica is indigenous to the hills of the mild-wintered, moist regions of central-eastern China.[34] It is the favorite tree of southern China today. At present the loquat is one of the important fruits of southern Japan. The production there is estimated at 20 million pounds annually.[35]

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33 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 250.

34 Ibid., p. 252.

35 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 450.

This fruit tree is of considerable importance in northern India. In Australia the cultivation of this fruit is limited to Queensland.[36] Throughout a large part of the Mediterranean region the loquat is abundant and highly successful; southern France, Italy, Sicily, and Algeria.[37]

The loquat is widely distributed throughout the Americas. Commercial culture extends from California and Florida to Chile and Argentina.[38] In Mexico, Central America, and the northern part of South America it is grown, usually in mountain valleys and on plateau elevations at 300 to 7000 feet.[39] Southern California is probably the most favorable region for loquat culture in the United States.[40] It grows well in the Gulf States, but in many regions frosts interfere with the production of the fruit.

To reach its greatest perfection the loquat requires particular climatic conditions. Climatic requirements are distinctly subtropical. The loquat requires cool weather during part of the year and a rainfall of 15 to 50 inches (with artificial irrigation where the dry season is severe, as in the

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36 Samuel Fraser, American Fruits, Orange Judd Publishing Company, 1924, p. 746.

37 Ibid., p. 746.

38 Ibid., p. 746.

39 Wilson Popenoe, Manual of Tropical and Subtropical Fruits, The Macmillan Company, 1920, p. 254.

40 Ibid., p.254.

Mediterranean Subtropical countries).[41] Wherever lemons can be grown, there the loquat will thrive, requiring the same temperatures; it will withstand even slightly lower temperatures than the lemon. The mild climate of seacoast areas within the Mediterranean Subtropical climatic belt is peculiarly favorable to the development of the fruit.

Loquats will grow on many soil types, but sandy loams of good depth are considered the ideal loquat soil.

Budding is the preferred method of propagation, though grafting is sometimes used. The orchard care needed is similar to that of citrus fruits. When the fruits are about one-half inch in diameter, the clusters are bagged for protection against birds and insects.[42] This is done in Japan, but is not often practiced by commercial growers. Budded or grafted trees are expected to bear commercial crops at five years.[43] The tree as a rule produces well each year. A mature tree should yield about 200 pounds annually.[44] Four to five tons per acre is considered a good crop.

The fruit should be left on the trees until fully ripe--usually for ten days after it has colored--to develop full

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41 Op. cit., p. 256.

42 Samuel Fraser, American Fruits, Orange Judd Publishing Company, 1924, p. 749.

43 Ibid., p. 749.

44 Ibid., p. 750.

flavor and aroma. Round-pointed fruit clippers are commonly used for clipping the bunches in harvesting. In California, harvesting and marketing takes place from late February to June; in Florida it is a bit earlier.

Loquat is distinctly a dessert fruit. It may be used fresh; sometimes it is made into jellies, jams, pies, and sauces.

The Mulberry. Although it is generally known that vast numbers of mulberry trees are grown to provide leaves as food for silkworms, it is not so well known that mulberry trees are also cultivated on a large scale in some parts of the world for their fruit--white, red, and black berries about the size and shape of a blackberry--for food for man and as forage for animals.

Two species of mulberry trees are raised--Morus alba (the white mulberry)[45] and Morus nigra (the balck mulberry).[46] Both are valued for their leaves and their fruits. However, the white mulberry is the only one cultivated to any extent and all further discussion will concern itself with this species.

The white mulberry is believed to be a native of the re-

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45 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 149.

46 Ibid., p. 152.

gion extending from northern China eastward as far as Japan.[47] Its original habitat is difficult to discover since birds are so fond of the fruit and bear the seeds to great distances.[48] In this way it is believed that the tree was introduced from northern China into the plains of the south where it is now an important tree in the life of the people.[49] From this general area the white mulberry was naturalized in northern India, Persia, Armenia, Asia Minor, and the northern Mediterranean area, later to be introduced into the United States.

The geographic distribution of the white mulberry is confined to the Humid Subtropical regions of Asia and southeastern United States, and to the humid parts of the Mediterranean type of climate in the countries of southern Europe. In Japan, Chosen, and China the mulberry is raised primarily for its leaves; the berries are prized as food, but because the trees are cut back to get leaves for the silkworms, the great majority bear little fruit. In the Mediterranean countries of southern Europe, both the leaves and the fruits are prized. In southeastern United States the trees are grown mostly to produce berries as forage for pigs.

The climatic requirements of the mulberry are those characteristic of the Humid Subtropical climate and the humid por-

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47 Op. cit., p. 150.

48 Ibid., p. 150.

49 Ibid., p. 150.

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47 Op. cit., p. 150.

48 Ibid., p. 150.

49 Ibid., p. 150.

tions of the Mediterranean Subtropical climate. This tree requires winters which are comparatively short and mild, long summers with high temperatures, and fairly abundant moisture, evenly distributed, throughout the summer in order to produce good leaf crops or heavy fruit crops.[50] However, only in the very populous countries or regions where human labor is cheap and plentiful are the mulberry trees raised for their leaf crops and the silk industry carried on. Where climatic and soil resources are favorable but labor costs high, the mulberry assumes the role of a pasture tree.[51] Since the tree grows fairly well even upon poor soils, the mulberry groves can be relegated to rather mediocre sandy or gravelly areas, or to steep slopelands, thus leaving the better lands in densely populated regions for food crops.

The mulberry is one of the most distinctive plants of Japanese agriculture and is basic to Japan's silk industry. Though in the natural state the mulberry maintains proportions of a full-sized tree, here and in other regions where it is cultivated for its leaves, the tree is pruned to bush size to facilitate the gathering of leaves.

In Japan the mulberry trees are cultivated from northern Hokkaido to southern Kyushu, but production is concentrated in

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[50] Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 537.

[51] Ibid., p. 538.

central Honshu.[52] The cultivation is widespread in the semi-tropical parts of Japan; but in the northern parts comparatively small areas are devoted to the crop because of lesser amount of precipitation and lower temperatures. Mulberry acreage is concentrated in Nagano, the land-locked prefecture which straddles the crest of the Japanese Alps in central Honshu. This region surpasses all other political units of Japan in the production of this crop with approximately 11 per cent of the mulberry acreage of the entire country. Within this interior highland prefecture there is an abundance of land unsuited to paddy rice--thin, stony, acid, infertile, and even sandy--but fortunately the mulberry will grow on this.[53] Not only is the mulberry acreage concentrated on the hill lands, but is also found on the inner margin of the intensively cultivated coastal plains, as well as on coarse alluvial fans, sandy outer margins of old beach ridges of deltaic plains, and stony soil between dual dikes.[54] The Suwa Basin of Nagano is a concentrated district of mulberry culture in this prefecture.[55]

Much of the land in Japan suited climatically to the mulberry is uncultivated with it because of distance from areas

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52 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 218.

53 Ibid., p. 218.

54 Ibid., p. 218.

55 Ibid., p. 219 (fig. 143).

of dense population. Without the presence of abundant, cheap, experienced labor the mulberry tree loses its importance for sericulture.

In the chief district of Japan a long growing season with high temperatures and a heavy, evenly distributed summer rainfall bring a flush growth of tender leaves as feed for the silkworms. Each house averages a mulberry field of less than an acre; yet, more than 15 million acres are in mulberry fields in that country.[56] Of all the cultivated land in Japan, excluding that used for rice, 30 per cent is given to mulberry cultivation.[57]

Three forms of mulberry are cultivated in Japan: low, middle, and high. The low form, a dwarf variety, buds early to mature quickly; it constitutes about 75 per cent of the total mulberry growth in Japan.[58] It has the advantage of making quick growth in the shortest period of time, does not shade the land so that other crops may be grown along with it, can be picked easier than the other two forms, and in harvesting may be cut back almost to the ground without injury. In cooler mountain regions only one crop of leaves is produced annually, but in warmer regions a second crop may be gathered. The lim-

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56 Op. cit., p. 220.

57 Ibid., p. 220.

58 Ibid., p. 220.

it for mulberry bushes in Japan is two leaf crops a year.[59] The low variety yields about 30 per cent less than the larger, slow-maturing varieties.[60]

Chosen has increased sericulture as a result of Japanese influence. Mulberry trees are widely scattered over the peninsula, but the greatest acreages are concentrated in southeastern Chosen.[61] Individual regions of mulberry concentration include the slopes in the lower Nakdong Valley, Chung Chun Valley, the lower hillslopes of the prefecture which straddles the Duk Yu San Mountains, and the lower hillslopes of the Chang Bak San Mountains.[62] Relief, soil, and climatic conditions favor the growth of this tree. As in Japan each family household raises the tree on the slopes, or as hedges around farm plots for a supply of the leaves.

In China mulberry production is concentrated in three major areas: the lower and middle Yangtze Valley and its tributaries, the Si Kiang Valley (Canton Basin), and the Min Valley (Foochow Basin).[63] Mulberry is for the most part carefully tilled. In some regions as much as one-third of the tilled land is in mulberry trees. Mulberry bushes spaced at intervals of six feet occupy the slopes and even flatland raised three to

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60 Op. cit., p. 221.

61 Ibid., p. 225 (fig. 147).

62 Ibid., p. 225 (fig. 147).

63 Ibid., p. 224.

to six feet above the level of the rice paddies. The trees are well fertilized with human waste, pond and canal mud, and silkworm excrement. In the lower Yangtze Valley trees yield three crops of leaves annually, but in the Si Kiang Valley, owing to a heavier, as well as more evenly distributed rainfall and a longer period of high temperatures, seven or eight yields may be realized.[64] In the latter section as much as 200 pounds of leaves may be procured annually from a single mulberry tree.[65]

The Bengal community of the lower Ganges Valley (India) is the chief area of mulberry tree production in India,[66] though several scattered areas exist toward the upper Ganges Valley.[67] Trees here produce six crops of leaves a year. Though India has several areas suitable for sericulture and has an abundant supply of labor, there is little likelihood that mulberry trees will be more extensively grown since there is a lack of skilled labor and scientific methods for sericulture.

The mulberry tree is found in most of the more humid parts of the Mediterranean region--southern Europe and western Asia--where the trees are grown for a limited production of silk. Here the increased industrialization, higher standards of liv-

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64 Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 224.

65 Ibid., p. 224.

66 Ibid., p. 225.

67 Ibid., p. 225 (fig. 147).

ing, and competition from the Far East have discouraged mulberry culture on any larger scale. Districts in which the tree is grown are chiefly in small basins or valleys which are protected from cool north winds: such as the Rhone Valley of France, the Ebro Valley of Spain, the upper Po Basin of northern Italy as well as small districts along the west coast of that same country and in eastern Sicily, the Vardar Valley of Jugoslavia and Greece, the northern part of the Maritza Basin and Arda Valley of Bulgaria, Bursa Basin of Turkey, the Antioch Plain of Syria, and the plains of Transcaucasia of southern U. S. S. R.[68] The three regions of greatest concentration of mulberry production are those in Spain, southern France, and more particularly northern Italy.[69]

In the upper Po Valley the trees are planted on the same land with other crops. In this region the winter temperatures are too low for the olive and the citrus fruits.[70] The mulberry, however, is hardy and with irrigation produces an abundant crop of leaves during the warm season. The leaves are picked early so that shade from the trees will not interfere with the growth of other crops. The dense population of this valley and the many small farms furnish the necessary conditions for a

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68 Op. cit., p. 225 (fig. 147).

69 Ray H. Whitbeck and Vernon C. Finch, Economic Geography: A Regional Survey, McGraw-Hill Book Company, 1941, p. 494.

70 Ibid., p. 494.

supply of cheap but skillful workers who carefully tend the trees. In the Po and Rhone Valleys the production of mulberry trees is subsidiary to fruit raising and other types of farming.[71]

The chief disadvantage of southern Europe and western Asia for growing mulberry trees for sericulture is that because of a short growing season and light rainfall trees yield leaves for but one brood of silkworms.[72] In general, the trees are not carefully tended and not pruned as are those of Japan and China. Most of the areas are handicapped by an inadequate supply of diligent workers and competition of other occupations.

The mulberry is a food of value among Asiatics--especially in parts of western Asia where dense population presses upon the resources heavily.[73] The trees bear so prodigiously that the ground beneath them is often carpeted with the fallen fruit. In Turkey and Syria during the short bearing season in the early summer both dogs and beggars sometimes take up their abode under the trees and live on the white mulberries for weeks.[74] Not only do people eat large quantities of the fresh fruits, but they also dry them during the long, hot, dry summers and

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[71] Clarence F. Jones, Economic Geography, The Macmillan Company, 1941, p. 226.

[72] Ibid., p. 226.

[73] J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p. 92.

[74] Ibid., p. 92.

make a flour out of which a kind of sweetmeat is made. Dried white mulberries, practically seedless and extremely palatable, form almost an exclusive food for hundreds of thousands of Afghans[75] for many months of the year; to them it is more important than bread is to people of the United States.[76] Dried mulberries have about the food value of dried figs, one of the great nutritive fruits.[77]

The fresh mulberries furnish an excellent food for pigs and poultry in the warm Humid Subtropical region of southern United States--throughout the Cotton Belt and the southern part of the Corn Belt.[78] At least one million square miles of this area are capable of producing crops of fruits from the everbearing strains of this tree. Therefore, it is looked upon as the "potential king of tree crops" for this part of the United States. To harvest mulberries costs nothing because the pigs and poultry gladly pick up the fruit themselves. Thus, mulberries, rather than mulberry leaves, fit especially well into American farm economics because labor costs in this country are high.

The advantages of the mulberry tree for our Southern States are: the tree is propagated easily; it bears early--the

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75 J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p. 92.

76 Ibid., p. 93.

77 Ibid., p. 93.

78 Ibid., p. 83.

second year, with profitable crops by the fifth year; the fruit is nutritious and may be harvested without cost; it is a regular bearer; it has a long fruiting season; it is an excellent forage crop.[79]

In our Southern States--particularly North and South Carolina, Georgia, Florida, Mississippi, Alabama, and Louisiana--the tree grows wild and in some places is cultivated to serve pigs as a "summer pasture tree".[80] One everbearing tree is said to be enough to support from one to three pigs during the fruiting season of two or more months. The ripe berries are available for forage from early May to late July, nearly three months.[81] It has been estimated that hogs fed on mulberries gained one or more pounds per day.[82]

Though the United States has the climatic and soil resources for the mulberry tree, economic and social factors will never allow its use beyond that of serving as a forage crop.

The Sweet Orange. The sweet orange (Citrus sinensis)[83] is the best known and most important of the citrus fruits. It seems that this fruit tree is a native of southern China and

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79 Op. cit., p. 84.

80 Ibid., p. 83.

81 Ibid., p. 86.

82 Ibid., p. 86.

83 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 431.

of Cochin-China, and from there spread to India and Europe, being carried to the latter place by the Moors or Portuguese before the 14th century. The Spaniards were responsible for its introduction into the New World.

The sweet orange is now grown in many places in both the tropics and subtropics the world over. In some regions the natural conditions are so favorable that the tree grows wild, as, for example, in Paraguay and in parts of Brazil. Citrus sinensis is widely distributed in some of the warm humid lands, especially in Japan and southern China, but the centers of commercial production are largely within the regions of the Mediterranean Subtropical climate. The development of the better types is on the coldward margin of the tropics where frosts are not unusual in winter; in tropical areas the oranges are of relatively poor quality, being somewhat acid and often greenish even when ripe. Where grown in the tropics, the orange is mainly for local consumption.

The growing of oranges has long been important in the countries of the Mediterranean Basin because climatically they provide a favored habitat for such a frost-sensitive crop. Within this area the producing districts lie mainly along the Mediterranean Coast, the irrigated valleys and coastal margin of the province of Valencia in eastern Spain being the leading center.[84] Southern Italy and Sicily, and the coast of Pales-

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[84] Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 494.

tine, near Jaffa, are other important producers of oranges.[85] Spain occupies the leading position as an orange-exporter from this general area. Palestine and Italy rank second and third, respectively.[86] Less important producers within the Mediterranean region are Algeria, Morocco, Tunisia, Greece, Portugal, southern France (Riviera), and Syria.[87] On the whole, the Mediterranean region promises to hold its place as one of the world's foremost orange producing areas, favored as it is by soil, climate, and ready accessibility to the world's greatest markets--northwestern, central, and eastern Europe.

Oranges have been produced on a commercial scale in the Union of South Africa and in southwestern Australia for a number of years, though the production is small as compared with the Mediterranean region.[88] Both of these areas have the Mediterranean Subtropical type of climate and raise oranges under irrigation. The fruit grown here have good keeping qualities and some are shipped to Europe, particularly the British Isles.

Except in Brazil, the production of oranges in South America is chiefly for home consumption. In Brazil the variety of orange known as navels are raised in the vicinity of the Paraná River. In recent years the planted acreage has been in-

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85 Op. cit., p. 494.
86 Ibid., p. 495.
87 Ibid., p. 495.
88 Ibid., p. 495.

creasing. Many are exported; Brazil has the advantage of marketing it during our summer--their winter. The navels of Brazil may become the competitor of the Valencias of Spain and the United States in the great import centers of the Northern Hemisphere.[89] In Paraguay, cultivated as well as wild sweet orange trees occur in large numbers in a region tributary to the Paraguay and Paraná Rivers.[90] In addition to natural propagation of the indigenous variety, seeds of Andalusian and Valencian varieties, introduced by Jesuits, have been scattered far and wide by man and bird, with the result that orange trees abound in many districts. The natives bestow very little care upon the tree; even within the zone of greatest production, orchards receive little attention. Despite this, the fruit is large, of excellent flavor, and juicy. So poor are facilities of handling and transportation that millions of oranges go to waste every year. Paraguayan oranges must meet severe competition from Argentine and Brazilian oranges in Buenos Aires, their principal export market.

China, the probable home of the orange, is an important producer of oranges; but most of the oranges are consumed locally and so do not enter into the channels of foreign trade.[91]

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89 Op. cit., p. 495.

90 Clarence F. Jones, South America, Henry Holt and Company, 1930, p. 294.

91 Nels A. Bengston and Willem Van Royen, Fundamentals of Economic Geography, Prentice-Hall, Inc., 1935, p. 495.

In southern Japan where the Humid Subtropical climate prevails oranges are grown, though by far the greater number include the bitter orange rather than the sweet orange.

The United States is the world's largest orange producing country.[92] There are two principal areas--namely, Florida and California--while lesser quantities are produced in Arizona, Texas, and Louisiana.[93] All regions are subtropical--either Humid Subtropical or Mediterranean Subtropical.

Central and southern Florida grow 35 per cent of the American oranges. Here orange trees are characteristic on the flat lowlands on both the eastern and western coasts of southern Florida, and also on the rolling central upland.

Two major orange districts occur in California: the northern (and less extensive) district occupies the foothill sites at the base of the Sierra Nevada Mountains where good air drainage serves as protection from frost, from San Diego northward to Mt. Shasta, to involve the Sacramento and the San Joaquin Valleys;[94] the southern (more extensive) district lies on the piedmont plain bordering the San Bernardino and San Gabriel Mountains and is divided into two sections--an eastern and western section.[95] The eastern section has a drier atmosphere and

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92 Op. cit., p. 496.

93 Samuel Fraser, American Fruits, Orange Judd Publishing Company, 1924, p. 609.

94 Ibid., p. 610.

95 Ray H. Whitbeck and Vernon C. Finch, Economic Geography: A Regional Survey, McGraw-Hill Book Company, Inc., 1941, p. 100

and produces mainly the winter and spring crop of seedless navel oranges; the western section nearer the coast has a more humid atmosphere and raises the larger part of the summer and early autumn crop of Valencia oranges. The orange crop from this latter portion is now more than half the Californian total, since the winter crop must compete in the eastern markets with Florida and Texas oranges, whereas summer oranges have no citrus competitors.

A third center of orange culture is along the Gulf Coast of Texas. Its one difficulty is the danger of freezes which result from unwelcome northers which sweep down to the Gulf from the cold interior. The Delta region of the Mississippi and the lower Rio Grande Valley of Texas produce over 2 per cent of our orange crop.

Climate--temperature and rainfall--are the determining features for the successfulness of orange culture. In the United States greatest enemy of the orange crop is frost.[96] Florida has great danger of frost occurrences because that state lies on the east side of the continent and so gets strong outblowing northwest winds from the high pressure area which develops over the continent in winter.[97] Severe frosts in

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96 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 370.

97 Ibid., p. 370.

1886, 1894, and 1899 ruined about three-fourths of the groves in the northern part of the state and caused new plantings further south, and at the same time gave a chance to California to develop this fruit industry. Again in 1922 a frost spoiled half the Florida crop and killed many trees, thus giving the industry another shove to the south. Despite the great danger from frost, the high quality of northern fruit and relative freedom from pests lead people to plant new groves even in areas that have suffered from its devastating work.[98] In California, frosts are less harmful than in Florida because the westerly and northwesterly winds come across the ocean and hence cannot become very cold in winter. Cold northeast winds which sometimes bring frosts are much less common than northwest winds. Wherever danger from frosts occur, orchard heaters are used for protection.

Oranges require temperatures which are tropical or subtropical. Unusually high temperatures may cause the fruit to drop from the trees.

The orange requires a large amount of water, especially at the period when the fruit is ripening. For best results, therefore, the crop ought to be located in regions of adequate late summer rainfall, or where irrigation is possible. Both the humid east-coast areas of Florida, China, and Japan have adequate late summer rainfall, but in such cases only produce one-

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98 Op. cit., p. 371.

sixth of the recorded orange crop. Where the summers are humid, the fruit tends to be bitter rather than sweet, and diseases frequently afflict the trees in this climatic zone. Dry west-coast regions having the Mediterranean type of climate require irrigation, an item of great expense, but the hot, dry, summer weather results in a sweet fruit.

Oranges will grow on a variety of soil types, but does best on deep, rich, easily-worked loam because it retains the moisture. Where the summer rainfall is ample, good drainage is important.

High winds are unfavorable to the orange crop, damaging the fruit as it is knocked against the branches, or it may cause the fruit to drop prematurely.

Proximity of the groves to railroads or boat landings is an advantage when it comes to shipping the crop to market.

Grafting, budding, layering, cuttings, or planting from seed are the methods of propagation employed. The first fruit appears in three to four years, but commercial bearing does not commence until the fifth to eighth years. The orange bears annually; the fruit matures a year after the time of blossoming. Once established, a grove will bear for twenty to thirty-five, even fifty years. However, maximum yields are usually reached between the fifteenth and thirty-fifth years. An average yield per acre for California and Florida is 150 boxes. Yields of 250 boxes per acre may be expected from a well-managed grove in

either California or Florida.

Harvesting commences as soon as the fruit is ripe. Formerly the fruit was picked green for shipment to distant markets, but with the many precautions now taken against bruising the fruit this is no longer necessary, and with tree ripening results in an improved quality of fruit. In Florida early varieties are ready in October; in California, in the northern section, ripening and gathering begins along in November and lasts for two months; in southern California the navel oranges are harvested from January to May, the Valencia later, ending in November.

Great care is exercised in harvesting oranges; each orange must be carefully clipped, not pulled, from the stem so that neither the skin nor the "button" on the stem end is cut, and care must be taken to prevent the branches of the tree from scratching the orange. The picker wears a canvas picking-sack over his shoulders. When it is full, it is laid in a field box and unbuttoned, which prevents injury to the skin of the orange that would occur if they were simply poured out of the sack.

Like other citrus fruits, oranges are cured before shipping. The skins are full of moisture when picked and in that condition do not ship well. Curing toughens the skin or rind, and as a result the fruit can be handled and shipped more safely. Curing is effected in about five days and consists of free circulation of dry, cool air among the oranges.

Picking, and later the grading and packing, is done by fruit growers' associations. The work of grading and packing is done in public or association packing houses, much of the work being accomplished by machinery.

The Peach. The peach is the second most important fruit grown in the United States, and is a favorite table fruit. The common peach (Prunus persica)[99] is believed to be a native of China where it has been grown for thousands of years; some authorities claim Persia as the native home.[100] From Persia the peach was introduced into Europe. The Spaniards are said to have brought it to America. It is now widely grown in both North and South Temperate Zones.

The peach is classed as a stone fruit. It is commonly somewhat smaller than an apple. The round yellow fruits have a velvety skin and a compressed, pitted, or furrowed stone. Nearly 300 varieties are grown in North America alone, but all are grouped into two classes: freestone and clingstone.

The peach is a low tree, rather short-lived, and so susceptible to frost injury and low temperatures that its distribution is rather limited. The Mediterranean Subtropical climate is best adapted for peach culture, though the fruit is also

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99 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 414.

100 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 222.

found growing successfully in the Humid Subtropical climate. For the Humid Continental--Long Summer Phase, only in regions where large bodies of water control the temperatures can the peach be safely grown. The Central Valley of Chile, the Cape Town district of South Africa, the warmer parts of Australia and New Zealand, and the Mediterranean countries of southern France, Italy, Portugal, Spain, and North Africa have peach orchards.

Within the United States the industry averages more than 50 million bushels yearly, being second to apples.[101] The major peach producing regions are limited in general to latitudes below 38° F. The early peach district of central Georgia has many orchards, located on hillslopes; this district produces nearly 10 per cent of our total crop.[102] The intermediate slopes of California supply 40 per cent of the peach crop of the continent.[103] The largest per cent of dried peaches of commerce, chiefly from freestone varieties, and nearly all the commercial canning peaches, primarily from clingstone varieties, come from California. Outside these two major areas peaches are grown safely only in regions where the climate is tempered by influences from nearby large bodies of water. The Great

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101 Ray H. Whitbeck and Vernon C. Finch, Economic Geography: A Regional Survey, McGraw-Hill Book Company, Inc., 1941, p. 92.

102 Ibid., p. 92.

103 Ibid., p. 92.

Lake district, including those northwestern counties of New York which border Lake Ontario, the island section of Sandusky Bay of Ohio, and the western shores of Michigan are in such a peach-growing region.[104] These three localities are often referred to as the late peach district.

The irrigated lands of western Colorado produce peaches. This fruit is raised in many other states by farmers--portions of New Jersey, Pennsylvania, Missouri, Alabama, Oklahoma, and Texas. Outside the commercial areas of production farmers have peach orchards, but conditions are often such that these orchards are maintained at great risks from frost injury. In 1935 a total of 52,380,000 bushels were grown in the United States, with southern California, Georgia, Michigan, New Jersey, Pennsylvania, New York, and Washington leading in production.[105]

The Great Lakes section of Canada--an extension of that which lies in the United States--has peach orchards, especially on the Niagara Peninsula and in other parts of Ontario, lying on the north shore of Lake Erie.[106] The western part of Nova Scotia is able to raise this fruit because of the tempering influences from the Bay of Fundy. In British Columbia, the

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104 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 222.

105 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 414.

106 Op. cit., p. 226.

lower Okanagan Valley has some orchards.[107]

The most important factor limiting regions of commercial peach production is climate.[108] Certain temperature requirements must be met. Winter temperatures seldom below -15° F. cause extensive bud killing.[109] Because of the early blooming habits, there must be security from late spring and early autumn frosts. Late spring freezes and frosts, especially near the northern limits of peach production, injure the fruit buds and may destroy the prospects of a crop. The orchards require particular attention during fruiting time, especially on the Pacific Coast where autumn frosts often threaten the crops. If temperatures come too close to freezing, heating pots are used to safeguard the crop.

The selection of the orchard site determines the success of future crop production. The best site for the peach orchard is above the immediate adjacent areas of land to insure good air drainage as a protection against frost.[110] In the winter and on frosty nights in the spring and fall, the cold air moves down the slopes from higher to lower levels. A difference of as much as 15° to 20° F. may be observed between the top and

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107 Op. cit., p. 226.

108 Ibid., p. 226.

109 Ray H. Whitbeck and Vernon C. Finch, Economic Geography: A Regional Survey, McGraw-Hill Book Company, Inc., 1941, p. 41.

110 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 224.

base of the slope. Sometimes as much as just a few feet in altitude may determine whether or not the crop will be saved during the spring frosts. Thus, higher parts of a tract are better adapted to peach-growing while lower slopes are hazardous.

Moisture may often be a limiting factor in the distribution of peach orchards.[111] Rainfall during the spring and summer months is most valuable to peach development. Regions with ample rainfall or facilities for irrigation are thus favored.[112] In the Great Plains the peach is absent due chiefly to a shortage of rainfall and the failure to develop satisfactory irrigation projects.[113] The Mediterranean Subtropical climate produces a solid fruit of high sugar content particularly well-suited to canning. Extremes of wetness or dryness reduce the vitality of the trees and induces winter killing.

Peaches are suited to a variety of soils, provided they are well-drained. Light soil on high or elevated ground, preferably sloping toward the north, west, or northwest, and, if possible, sheltered from wind, is favored.

In the United States the common way to raise peaches is to sow the seed, though different varieties are propagated by bud-

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111 Op. cit., p. 224.

112 Ibid., p. 224.

113 Ibid., p. 224.

ding on seedlings of wild peaches from North and South Carolina and Tennessee. Peach trees fruit in the third year of growth, though commercial crops are not produced until the fourth or fifth years. The average duration of yield is ten years, though where irrigation is practiced some trees bear fruits for fifteen to twenty years. The average yield per acre is 280 bushels of fresh peaches.

Peaches for home consumption are best when tree ripened: in the southern regions, late July; in the northern regions, late August and early September. Fruit to be sent to market must be so timed in picking that it will reach it not overripe. The fruit must be picked with great care so as not to be injured. Two or three harvestings are necessary for each orchard. After the fruit is inspected, the satisfactory ones are sized, graded, and packed into baskets for shipment.

For canning, the skin is removed from tree-ripened peaches of the clingstone variety by dipping into lye solutions which causes it to come off quickly in the hands; next, the pits are removed by peach-pitting machines and the peaches are ready for packing into cans. California leads in the canning of peaches, 60 per cent of its crop being canned.

For drying, freestone varieties of large size and high sugar content, those which are pulpy rather than juicy, with flesh of a rich golden-yellow color and pleasing flavor are desired. Practically no part of the eastern crop is dried. California

leads in dried peach production, the normal output being about 30,000 tons of dried peaches. California can sun-dry peaches because of the hot, dry summer climate. Australia and South Africa are increasing their output of sun-dried peaches and are following Californian methods of drying and marketing.

After the peels have been removed, the peaches are split and the pits removed; then the halves are laid cup side up on shallow flat trays. Following a three hour exposure to fumes of burning sulphur, the trays are placed in the sun in the permanent drying yards. Finally, the dried fruit is graded, cleaned, and stored into a mass to "sweat"--a process making the fruit uniform in moisture content. It takes four to seven pounds of fresh fruit to furnish one pound of dried.

Fresh peaches find markets in the cities of northeastern United States and also in northwestern Europe. South Africa markets its peaches--fresh, dried, and canned--in Europe and the United States in February and March. England imports this fruit from the Mediterranean regions of production.

Besides its many uses as a fruit, both fixed and volatile oils, akin to almond oil, are obtained from the seeds. During World War I peach stones were used as a source of charcoal for gas masks.

The Nectarine. The nectarine is a hairless peach, but in other respects it resembles the peach, being smaller than the

peach, and has a firmer flesh of a more distinct and finer flavor. Peach pits may give rise to nectarines and nectarine pits may give rise to peaches.

Nectarines are generally grown on the Pacific Coast rather than in the eastern states. California is the seat of the industry. Some varieties have been introduced which can be grown in Texas.

The climatic conditions necessary for the production of this fruit are similar to those of the peach. The nectarine is not, however, as hardy as the peach.

Nectarines are eaten in a variety of ways: fresh, canned, and dried. This fruit as yet is raised only in quantities sufficient for home use.

The Persimmon. Persimmon trees are of two general types: Diospyros kaki (the Japanese persimmon) and Diospyros virginiana (the American persimmon).[114] Both varieties are to be found in the Humid Subtropical and Mediterranean Subtropical climates.

Diospyros kaki. This species of persimmon, more commonly called the Japanese persimmon, is a native of China. It is a major fruit crop and a standard food in the Orient. It is widely cultivated at present in China and Japan, in tropical coun-

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114 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 455.

tries of Asia, and to some extent in France and other Mediterranean countries as well as in our southern states--Florida, the Gulf States, and California. In recent years this variety of persimmon has become a familiar fruit in our city markets where it has met with considerable favor. The Japanese persimmon attains the size and color of our common red tomato.

Diospyros kaki can grow wherever the fig tree grows. It thrives in the humid subtropical areas and also in the dry subtropical areas. It is able to endure semi-arid conditions in California because of its long tap root. The best soil is one which is deep, somewhat heavy, of good drainage, and a fair amount of humus.

This variety of persimmon is harvested before fully ripe, before it softens, so it will stand long-distance shipments. The fruit is cut from the tree with orange clippers and must be handled with care to prevent damage or bruising. In Florida and California the harvesting season is from August and September to December.

When properly ripened, the fruit is excellent to eat raw. The flesh is jelly-like and is eaten with a spoon. It may be cooked and made into puddings and marmalades.

In Florida the fruits are kept in carbon dioxide for two to seven days to make them non-astringent; in Japan they are placed in casks formerly used for holding saké, for five to fifteen days.

Persimmons may be dried. The fruit is peeled with nickel-plated knives since iron knives stain the fruit. Drying in the United States is done artificially, at temperatures not exceeding 122° F. In this country dried persimmons are regarded as a very attractive commodity and it is felt that when problems of drying are solved, the future for commercial production of this variety of persimmon will be much brighter. In China, drying is confined to valleys in the provinces of Shantung, Shansi, Honan, Shensi, and Kansu.[115] Here the fruit is peeled and strung, and then left hanging from poles in the sun. To the Chinese this fruit is the dried prune and dried fig; it is generally relished by foreigners.

Diospyros virginiana. This is the American variety of persimmon and is found wild over the southeastern quarter of the United States, the region of which it is native. The persimmon grows over a region a million square miles in the United States.[116] It is common in our South Atlantic and Gulf States, growing as far north as eastern Kansas, southern Ohio, and southern Connecticut. The fruit of this persimmon tree is one-half to two inches in diameter and pale orange or yellowish in color; it is sweet and delicious when ripe, especially when touched by frost, but it is very astringent when green. When

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115 J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p. 96.

116 Ibid., p. 96.

grown abundantly in the United States, the fruit of this tree is used mainly as forage for farm animals; millions of people eat them occasionally with relish, but it has not as yet become an important fruit crop in this country.[117]

The persimmon has great climatic range.[118] It has extreme catholicity as to soil, thriving on sandy, clay, stony, rocky soils and even in muck land where water stands part of the year. The tree fruits at an early age--three to four years of age--and bears profusely with great regularity. One tree which was twenty-six years old was claimed to yield five bushels.[119] The fruiting season is remarkably long--from August to February. There is no cost for harvesting the fruit since they drop from the trees and animals can roam under the trees and pick up the fruit at will during this long season.[120]

Diospyros virginiana has two great opportunities in American agriculture, as a forage crop and as human food; but because the ripe fruits are somewhat pulpy and hard to transport, it is more favorable in this country as a pasture tree for farm animals.

The Tangerine. The tangerine, a variety of mandarin orange, is adapted to regions with either the Humid Subtropical or Med-

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117 Op. cit., p. 95.
118 Ibid., p. 96.
119 Ibid., p. 105.
120 Ibid., p. 95.

iterranean Subtropical climate. The tangerine resembles a small, sweet, reddish orange, with a skin almost completely separated from the pulp. Its name comes from Tangier in Morocco, and the fruit is common in North Africa.[121] The fruit is grown commercially in California, Florida, and the Salt River Valley in Arizona,[122] but the production is not large because there is no great demand for it in the United States. In Japan and parts of China, on the other hand, it is the most abundant of all fruits.[123]

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121 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1935, p. 372.

122 J. Russell Smith and M. Ogden Phillips, North America, Harcourt, Brace and Company, 1940, p. 593.

123 Op. cit., p. 372.

CHAPTER XIV

TREE CROPS OF THE DRY SUBTROPICAL CLIMATE

Climatic conditions are adverse to tree growth in regions having a Dry Subtropical Type of climate; but because of their adaptability to arid and semi-arid conditions such as exist throughout regions under the influence of this climate two tree crops merit attention in this climatic classification: mesquite, a tree legume; and pinon nuts, an edible nut.

Mesquite. The mesquite is considered the tree crop with a future. For a long time it has served as food for both man and beast. J. Russell Smith sets forth the belief that this tree legume has the possibility of becoming one of the major crops of American agriculture. At present it shows great promise since its cultivation can, if scientifically practiced and improved, be extended over a wide territory where conditions very adverse to ordinary crop production exist.[1]

The mesquite (Prosopis glandulosa) and a related species, the keawe (Prosopis chilensis) are native to the arid and semi-arid regions of the West Indies, Mexico, and Central America. The trees are members of the bean family, bearing long, straight or sometimes spirally twisted, screw-like pods which contain

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[1] J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p.

bean-like seeds and have a high sugar content.

Mesquite is found growing wild from southwestern desert regions of the United States southward to Chile and Argentina.[2] In the United States the area of bean-bearing mesquites is roughly from the Colorado River to the Brazos River in Texas on the east, to the western edge of the Colorado Desert in California on the west, and from the northern boundaries of Arizona and New Mexico southward into Mexico--a subtropical desert and steppe region between California and the so-called Cotton Belt.[3] The drier parts of Mexico have mesquite trees. The trees are found in a number of places in South America; scattered patches of mesquite exist along the dry coast of northern Colombia and western Ecuador, along the stream courses on the western lowlands and savannas of Bolivia, in the Chaco of northern Argentina and Paraguay, and in nearly all parts of Argentina between 30° and 40° South Latitude. In the eastern Mediterranean the mesquite-producing region includes large areas of the warm arid portions of Syria, Persia, and Afghanistan.[4] Similar regions of large size produce mesquite in Australia.[5] It has been introduced into India and South Africa where it is attracting favorable attention. Mesquite has been introduced

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[2] Op. cit., p. 72.

[3] Ibid., p. 72.

[4] Ibid., p. 34.

[5] Ibid., p. 35.

into the Hawaiian Islands--there called keawe or Hawaiian algoroba--and now covers 50,000 acres and has become one of the most valuable trees on the islands.[6] Here it is limited to the arid and semi-arid lands close to sea level.

The various species of Prosopis are limited to tropical and subtropical regions of arid and semi-arid conditions. The mesquite grows rapidly and resists droughts by means of small water consumption and two distinct root systems: one spreads laterally in every direction, availing itself of occasional moisture coming from sudden, heavy, penetrating rains; the other, known as the tap-root system, is of great depth--from 50 to 80 feet--striking straight down to great depths and presumably feeding on deep ground water supplies. Mesquite endures all kinds of soils except that which is wet. It is more common on flats or plateaus than on mountains, though it grows to some extent on foothills. The tree can utilize arid, barren ground where no other crop will grow.

The mesquite is a good bearing tree, producing 50 to 150 pounds of beans per tree of good size;[7] in India 250 pounds of ripe pods per tree have been obtained.[8] It has been estimated that one acre of mesquite fed to cattle produces 1600 pounds of

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6 J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p. 37 (footnote).

7 Ibid., p. 77.

8 Ibid., p. 78.

beef, while one acre of corn or alfalfa produces only 450 pounds.[9] In addition to high productivity the tree is a very regular bearer. In Arizona and Texas two crops a year are produced; the early crop ripens during the first half of July and the second, during the first half of September.[10]

Many and varied are the uses of the mesquite bean. In the United States it serves as cattle-feed, being greedily eaten either directly from the tree or from under the trees by the domesticated animals, especially by horses, cattle, burros, goats, and even hogs. The beans are especially valuable because they ripen in August at the very time when drought may be expected to reach its worst. After harvesting, the mesquite beans may be made into bean-cakes, like cotton-seed cakes, and have been found to be of exceptionally high value as feed for all classes of stock and looked upon as very fattening.

In Mexico the beans are ground and used by the Indians and Mexicans for mesquite bread, supplying them with a nutritious food. In South America it is prized as an article of food in the human diet, and as cattle feed in Ecuador, the Chaco and the savannas of Bolivia. In northern Colombia, Ecuador, and Peru the beans, being rich in tannin, are gathered and made

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9 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 361.

10 J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p. 79.

into tanning materials for domestic use or to be used in the manufacture of dyestuffs and coloring materials.

Piñon Nuts. Few people think of pine trees as a source of human food in the form of edible nuts. The piñon pine is one which produces a nut which is widely eaten. The pine nuts or piñons are the edible nut-like seeds of the cones of several species of Pinus which are native to southwestern United States (Rocky Mountains and Pacific Coast regions) and northern Mexico. These popular nut-like seeds which are enclosed within a thin brownish-red shell are about the size of a bean, and are large, sweet, and oily.

Two species of piñon pines are important producers of pine nuts: the Rocky Mountain piñon (Pinon edulis), a two-leaved species which forms large, open forests from Colorado and Utah southward to Mexico; and the single-leaved piñon (Pinon monophylla) which grows on the desert slopes from Utah to California and southward.

The piñon trees are scattered over a half-million square miles in our Southwest and northern Mexico (from the states of Utah and Colorado southward to central Mexico) growing wild in the drier edge of all forest belts within that area. The Colorado and Mexican Plateaus are involved.

The piñon is one of "Nature's great gifts to man"; this is so since it will grow almost anywhere that a tree will grow in

the arid subtropical regions.[11] It grows to good advantage in a climate that is hopeless for agriculture without irrigation and where pasture is of low-yielding power. The piñon is perfectly at home on steep hill slopes even though they are dry and rocky; it is the first tree found at the dry timber line. Therefore, after all irrigable areas are used, the greatest possibility of increased production in the southwestern plateaus is in tree crops, and the piñon has great possibilities.

As yet the harvesting of piñon nuts is a forest-collecting industry, the natives--chiefly Mexicans and Indian women and children--gather the nut-filled cones into large conical baskets from the wild, open forests or groves. The typical cone yields about thirty-four seeds, and a good tree will produce 1000 cones, or about 34,000 seeds.[12] After the cones have been gathered, they are roasted so that the scales will fall apart and allow the seeds to separate from the cone. The nuts are then removed from the cones and spread out in the sun to dry thoroughly.

For ages the piñon nuts have been a mainstay for the native Indians and Mexicans, furnishing both a fat and protein food for their diet. When the railroad came into the southwest

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11 J. Russell Smith and M. Ogden Phillips, North America, Harcourt, Brace and Company, 1940, p. 579.

12 C. Langdon White and George T. Renner, Geography: An Introduction to Human Ecology, D. Appleton-Century Company, 1936, p. 146.

the Indian found a market for his nuts, and then the nuts were shipped by the ton, carload, almost by the trainload. Pinon nuts are rapidly coming into world trade,[13] and shipments from New Mexico alone have reached 7,000,000 pounds in a good crop year. On the average one to two million pounds of piñon nuts are consumed annually. The annual harvest in Colorado, Utah, Arizona, and New Mexico amounts to tens of thousands of dollars. Nevertheless, large quantities are not gathered, and still either go to waste or support myriads of squirrels.

Exponents of tree crop agriculture predict that nut-bearing pines, including the piñon will have much greater importance in the future because of their adaptability to unirrigable areas and steep hillslopes.

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13 J. Russell Smith and M. Ogden Phillips, North America, Harcourt, Brace and Company, 1940, p. 579.

CHAPTER XV

TREE CROPS OF THE HUMID CONTINENTAL CLIMATES

The two Humid Continental climates--The Long Summer Phase and The Short Summer Phase--are similar in all climatic aspects with one exception--the length of their summers. Therefore, the kind of trees and, naturally, the kind of tree crops in both are for the most part the same. Because of this, the tree crops of both phases of the Humid Continental climate have been combined in this chapter.

Both of these Humid Continental climates are rich in crop-yielding trees. Not all tree crops present in these climatic types, however, are being exploited for commercial purposes. Many have been untested and almost unexplored from the standpoint of economic botany. When tree crops from other climatic regions are exhausted, unavailable, or restricted because of cost or other reasons, greater attention will be turned to the development of tree crops within this general climatic zone.

The tree crops which are characteristic of both phases of this climatic regime provide the markets of the North Temperate Zone with medicinal products, dyes, fruits, essential oils, gums and resins, flavoring materials, sugar, tanning materials, a tree legume, and edible nuts.

DRUGS AND MEDICINAL PRODUCTS

Slippery Elm. The inner bark of the slippery elm (Ulmus fulva), a large deciduous tree native of eastern North America, is the source of a non-poisonous drug.[1] Its natural range in eastern North America is extreme. It grows in the forests from Maine and the lower St. Lawrence Valley in Canada westward across southern Ontario to eastern South Dakota and southward to western Florida and eastern Texas.[2]

This species of elm prefers rich, moist, alluvial, well-drained soils, and is found most frequently along stream banks and on low, fertile, wooded slopes.[3] It may even be found on rocky ridges or limestone outcrops--such sites, however, making poor growth. The region of greatest abundance and greatest size is probably the Great Lakes states[4] where environmental conditions are most nearly ideal.

The inner bark of the slippery elm is whitish and strongly mucilaginous. This mucilage is used for its soothing effect on inflamed tissues, either in the crude state or in the form od lozenges. For the preparation of this medicinal product the bark of the tree is removed in spring; the outer layers are discarded while the inner portion is dried for manufacturing.

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1 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 263.

2 George H. Collingwood, Knowing Your Trees, American Forestry Association, 1941, p. 158.

3 Ibid., p. 158.

4 Ibid., p. 158.

Such stripping of the trees has resulted in the destruction of many of these trees.

DYES AND PIGMENTS

Quercitron. The crushed bark of the black oak (Quercus velutina), one of the common and largest of the eastern oaks, yields a yellow dye known as quercitron.[5] The tree is familiar in eastern United States; the range extends from southern Maine and northern Vermont westward through southern Ontario, southern Michigan to southeastern Minnesota, and southward to northern Florida, west to eastern Texas, eastern Oklahoma, eastern Kansas, southeastern Nebraska, and Iowa.[6]

In the upland cutover forest areas the tree is the most abundant species, and though it prefers rich, well-drained, gravelly soils, the black oak is not usually found in great abundance in the better soils of slopes because it is very intolerant to shade.[7] It is most often found on the poorer soils of slopes and ridges, the young trees developing long tap-roots that enable them to survive where many species would suffer from want of water.[8]

The outer bark of the mature trunk, three-fourths to one and one-fourth inches thick, is of no value; the thin inner

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[5] Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 148.

[6] Op. cit., p. 138.

[7] Ibid., p. 138.

[8] Ibid., p. 138.

layer of bark is deep-orange, very bitter to taste and rich in tannin. It is from the deep-orange inner bark that the yellow dye commercially known as quercitron is made. The bark for both tannin and dye is collected chiefly in Georgia, the Carolinas, and Pennsylvania.[9] The bark is usually crushed into a fine brownish-yellow powder. This may be decomposed into quercitrin, an extract.[10] Both the extract and powder are used commercially for dyeing cotton and woolen goods.[11]

FRUITS

The Apple. No other fruit is so widely distributed geographically as the apple, being now grown in every temperate climate of the world. There are over 1400 varieties of apples with the fruits varying in size, color, texture, and flavor.

The species Pyrus malus from which the cultivated apple originated is believed to be native to the region of the Caspian Sea and adjacent parts of southeastern Europe.[12] A wild apple is especially common in northeastern United States and southwestern Canada, though it is not native there.

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9 Charles R. Toothaker, Commercial Raw Materials, Ginn and Company, 1927, p. 184.

10 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 419.

11 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 148.

12 Alphonse De Candolle, Origin of Cultivated Plants, D. Appleton and Company, 1885, p. 234.

The apple is commercially important in the United States and Canada, the continent of Europe, and Australia.[13] Apples are also produced in eastern Asia, South Africa, Chile, and Argentina, but not in large quantities.[14] All apple-producing regions lie either in the Humid Continental or Marine West-Coast climates.

The apple is by far the most important fruit crop of North America--the United States and Canada--in terms of land area occupied, and in volume and value of products.[15] The average apple crop of the United States and Canada is nearly 200 million bushels of which one-half to two thirds may be called "commercial" crop.[16]

In the United States no other fruit is so widely distributed geographically. Commercial apple-growing prospers in those districts that are in some way favorable or for which special markets have been created by human enterprise. There are six such apple districts within the limits of the United States.

One such district is the New England Baldwin belt, which

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13 Ellsworth Huntington, Frank E. Willeams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 377.

14 Ibid., p. 377.

15 Ray H. Whitbeck and Vernon C. Finch, Economic Geography: A Regional Survey, McGraw-Hill Book Company, Inc., 1941, p. 85.

16 Ibid., p. 85.

extends from Maine to Connecticut.[17] Here the orchards occupy rough lands and relatively granitic soils or stony glacial deposits, and are not so productive as some of the larger and better situated orchards of the west. This belt fulfills the market demands of New England and New York.

A second apple-growing district is the Hudson River Valley and Lake Champlain District of New York state.[18] This district has the reputation for quantity and quality and the advantage of proximity to markets of the northeast.

The orchards of the Appalachian District add a third important apple district.[19] It extends from Pennsylvania to northeastern Georgia, including the Shenandoah-Cumberland Valley Region and the Piedmont Region along the eastern front of the Blue Ridge of Virginia through the Carolinas and into Georgia. More than half the apples which are produced in this belt come from the northern portion of the belt.

The leeward shores of the Great Lake District is a fourth region of apple production.[20] Here the lakes serve as regulators of temperature and moisture on their leeward shores. The blooming of the trees is delayed in spring by cold winds from over the lakes until the season has progressed so that killing

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17 Op. cit., p. 86.
18 Ibid., p. 87.
19 Ibid., p. 88.
20 Ibid., p. 88.

frosts are not likely to occur; and in autumn the heat radiated from the lakes delays the occurrence of frost until after the fruit has been harvested. The areas involved in this district include western New York and western Michigan.[21] In western New York the commercial orchards are on the glacial lake plain, a belt 10 miles wide and extending for 125 miles eastward from Niagara Falls. This region formerly was the most important apple district in the United States. The fruit belt of western Michigan resembles that of New York in geographical aspects, but its markets lie mainly to the west.[22]

The Central Plains apple region consists of isolated districts in southern and western Illinois, the Ozark Highlands, and in Missouri and Arkansas River Valleys.[23] Because of the damage due to cold weather in spring, during the budding period, the orchards are placed on hillslopes for the benefit of air drainage.

The irrigated apple orchards of the West--from the Pecos Valley in New Mexico to the Okanagan Valley in British Columbia--provide 40 per cent of the commercial apples of North America.[24] Within this area apples are produced in small irrigated

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21 Ray H. Whitback and Vernon C. Finch, Economic Geography: A Regional Survey, McGraw-Hill Book Company, Inc., 1941, p. 88.

22 Ibid., p. 88.

23 Ibid., p. 88.

24 Ibid., p. 90.

orchards of a highly specialized character: the Grand Valley of California; the Wenatchee and Yakima Valleys of Washington (on the dry sunny east slopes of the Cascade Range) which supply half the western apples on the markets; the Willamette and Hood River Valleys of Oregon.[25] As compared with the less intensively cultivated orchards of the East these have several important advantages:[26] frost damage is not so common; fungus diseases are more easily controlled than in the humid areas of the East; the control of the water supply causes heavy yields; and the high proportion of sunny weather which produces a highly colored fruit of dessert character.

In southern Canada there are three commercial apple districts: the Annapolis-Cornwallis Valley of Nova Scotia--the peninsular character of the province affords the protection of a marine climate, and its location near its market England are two advantages of the region;[27] the Niagara Peninsula of Cntario and the north shore of Lake Ontario--this region is benefited by location on the leeward shores of the Great Lakes; and the Okanagan Valley of British Columbia.[28]

A number of countries in northwestern Europe are important in apple production: England raises a good many; the Rhine Valley is an important producer as well as the adjacent territory

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25 Op. cit., p. 89.
26 Ibid., p. 89.
27 Ibid., p. 87.
28 Ibid., p. 90.

in France, Germany, Holland, and Belgium; Switzerland and Austria are also contributors to the European supply.

In Australia, South Victoria and Tasmania, many apples are produced, the two regions having climatic conditions resembling those of the Willamette Valley of Oregon. The former region furnished 2 million bushels in 1939-1940, while for the same period the latter produced 6 million bushels.[29] The principal market is Great Britain.

In eastern Asia apples are commonly grown by Chinese farmers in the upper Yangtze Valley and other cooler parts; and also to some extent in Manchuria, Korea, and Japan.

South America has two areas where apples are grown: in middle Chile, where the apple finds especially suitable conditions in the cool moist region between 38° S. and 41° S.;[30] in Argentina, in a strip about 50 miles wide from south of the La Plata to north of Buenos Aires, the apples are grown on large estates by immigrant labor or on farms of 25 acres or less in the suburbs; the Rio Negro Valley is also an important apple district.[31]

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29 Ray H. Whitbeck and Vernon C. Finch, Economic Geography: A Regional Survey, McGraw-Hill Book Company, Inc., 1941, p. 608.

30 Clarence F. Jone, South America, Henry Holt and Company, 1930, p. 144.

31 Ibid., p. 357.

Several natural and economic factors are involved in determining the regions of commercial apple development. Climate is the most important of the natural factors: the most determinative element in climate as it relates to apple production is temperature;[32] the availability of water through rainfall or irrigation is next in importance in limiting or extending production. Both of these two factors may be markedly influenced by elevation and topography.

The northern limit of the apple belt is determined by an average winter temperature of 13° F.; the southern limit, by the summer heat and humidity, and roughly coincides with the average summer temperature of 79° F.[33] In southern regions due to higher elevations conditions are favorable while at the same latitude apples are not grown successfully. A suitable climate is one that does not vary more than 20° F. a day.

In the geographical distribution of apple-growing moisture is often a limiting factor. At least 18 inches of rainfall are required in the humid sections, and adequate irrigation facilities are necessary in the arid and semi-arid regions.[34]

Elevation is often restrictive in the geographic distribution of apples. With few exceptions they cannot be grown at an

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32 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 211.

33 Ray H . Whitbeck and Vernon C. Finch, Economic Geography: A Regional Survey, McGraw-Hill Book Company, Inc., 1941, p. 86.

34 Ibid., p. 86.

altitude much greater than 5000 feet above sea level.[35] Hillsides are preferred to valley floors in some localities because they provide good air drainage.

Apples are successfully grown on a variety of soils; the only requirement is that the soil must be moderately porous with free underdrainage; it does best on strong and heavy loams but will not thrive on very dry or sandy types.[36]

Apples are grown on trees which have been grafted or budded on seedling root stock. In three to six years they begin to bear commercial crops. An orchard of standard apple trees will produce 100 to 800 bushels per acre, or 175 barrels.

Apples are harvested when "hard ripe" by careful handpicking methods. After harvesting, the fruit is sorted and sized by hand or mechanical sizing machinery either in the orchard or in special packing houses. On the Pacific Coast community or cooperative packing houses are common and gaining in popularity in other parts of the country where fruit growing is more or less centralized. The major part of the crop is sold to be eaten out of hand. Some, especially in New England, is made into applesauce. In the western states apples are being dehydrated and sun-dried.

Of the normal annual yield of about 200 million bushels in

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35 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 211.

36 Ray H. Whitbeck and Vernon C. Finch, Economic Geography: A Regional Survey, McGraw-Hill Book Co., Inc., 1941, p. 86.

this country and Canada, less than half is shipped to distant markets.[37] The farms and villages of the United States are the great centers not only of the production but likewise of the consumption of this fruit. England, though it raises a good many apples, also imports them from the European continent, Canada, the United States (particularly from New England), and Australia. Argentine apples have been sold mainly in Brazil, Germany, and Sweden.

The Cherry. The origin and introduction of the cultivated cherry is shrouded in mystery. It is believed that it originated in the region south of the Black and Caspian Seas, in western Asia, and eastern Europe.[38]

The cultivated varieties are divided into two main groups: the sweet cherry (Prunus avium) and the sour cherry (Prunus cerasus). The fruit of the sweet cherry is usually black or yellow, having a sweet pulp when ripe; that of the sour cherry is dark red in color, having a sour or acid taste. The former is primarily a dessert fruit but it is canned in considerable amounts; the latter is used almost exclusively for culinary purposes.

Cherries are grown for commercial purposes in the Mediterranean region of Europe, northern Africa, and Asia Minor; in

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[37] Op. cit., p. 366.

[38] Alphonse De Candolle, Origin of Cultivated Plants, D. Appleand Company, 1885, p. 206-7.

continental Europe, especially in Czechoslovakia; but most importantly of all in the United States. Thus this fruit is not limited to one climatic region, but may be grown in the Mediterranean Subtropical climate, the Marine West-Coast climate, and the Humid Continental climates.

On the whole, the production of cherries is well distributed over the United States. Sweet cherries which are sensitive to climate are more restricted in distribution. They are grown extensively in the Willamette Valley of Oregon and in the north to south valleys in the Cascades of Washington;[39] here the production of the sweet cherry has been made a specialized industry. The sweet cherry thrives in the well-drained alluvial soils of the lower Sacramento Valley of California. These Pacific regions produce about one-third the total cherry crop of the United States. Outside the Pacific areas sweet cherries are grown only in limited sections of the East: the Hudson Valley, western New York, and western Michigan.[40]

The sour cherry belt is practically coincident with the Corn Belt. This type of cherry is hardier than the sweet cherry in respect to cold and drought. The growing of the sour cherry is relied on as a substantial industry in western New York and in the Hudson Valley. Rather heavy plantings of the

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39 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 228.

40 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 377.

sour cherry are found in the Mississippi and lower Missouri Valley Regions.[41] Commercial plantings of this type of cherry exist in the Arkansas River Valley in Colorado, and in Door County Peninsula of Wisconsin.

The sweet cherry is rather sensitive to climate and soil. The blossom buds are easily affected by low temperatures and so are confined to districts near bodies of water which have tempering influences, to protected valleys in regions with cool moist climates. The tree does not thrive or fruit well in dry, hot sections of the United States or where long summers prevail.[42] The sweet cherry is usually more profitable in the higher altitudes where cool nights and warm days exist.[43] The northern limit of this type of cherry is like that of the peach. The sweet cherry tree thrives on a small supply of water, but will not do well in dry climates unless irrigated. Excessive water shortens the life of the tree. Therefore, well-drained, deep loam soils are best.

The sour cherry tree is hardier than the sweet, particularly with respect to cold and drought resistance. Its northern limit corresponds in general to that of the hardy types of apples. The northern part of Arkansas and Tennessee represents

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41 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 228.

42 Ibid., p. 229.

43 Ibid., p. 229.

the approximate southern range of production for both sour and sweet varieties. Sour cherry trees thrive on a diversity of soils; so long as the soil contains moisture this species will grow in a dry climate and withstand heat or cold.

Both varieties of cherry are propagated almost entirely by budding. Sour cherry trees are usually fertilized more heavily than the sweet which are able to get along without much manure or fertilizer. The period of gestation for both types is three to four years. Commercial bearing starts in the fourth year and trees yield crops annually for 50 to 100 years.

If the fruit is to be used by canneries, it is allowed to develop full color on the tree; that which is to be shipped to fruit stands must be harvested earlier and with more care. For canning, the sour cherries are often pulled off without the stem; cherries to be marketed for dessert must have the stem left on. Picking is done by hand or sheared off, except when used for canning. Much labor is required in harvesting the cherry crop as the picking season is comparatively short. The grower must be sure of plenty of help beforehand as the fruit is picked all at once.

Yields of 40 to 60 bushels per acre are considered as average. In California a single tree averages one-third bushel of cherries. In western New York three to four tons is considered a good yield per acre.

In 1935 the United States produced 117,430 short tons of

cherries.[44] This commercial crop came largely from New York, Michigan, California, Washington, and Oregon. Most of the commercial crop was marketed in the northeastern part of the United States.

The Pear. The common pear (Pyrus communis) is another of the important temperate fruits. Like the apple, the pear is a native of the temperate areas of southwestern Europe, from the Atlantic to the Caspian Sea,[45] but now is grown in temperate regions in all continents, growing further poleward than peaches but not so far poleward as apples.

Commercial pear culture is important in the United States, but much less important than the growing of apples. The total average crop is only one-seventh as great as the apple crop, partly the result of the poorer shipping and keeping quality of pears. Nearly two-thirds of the pear crop of the United States is now grown in the protected valleys in the three Pacific Coast states: the Sacramento Valley in California; the Rogue River and Hood River Valleys in Oregon; and the Yakima Valley in Washington.[46] The rest of the commercial crop comes from the eastern part of the country: the shores of the Great Lakes,

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44 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 436.

45 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 216.

46 Ray H. Whitbeck and Vernon C. Finch, Economic Geography: A Regional Survey, McGraw-Hill Book Co., Inc., 1941, p. 90.

particularly northern New York and the southwestern part of Michigan, which produce most of the eastern crop; the Hudson River Valley of New York; and the coastal plains of southern New Jersey, Delaware, and Maryland.[47] West of the Mississippi pears are grown under irrigation in Mesa County in Colorado and near El Paso, Texas.

Pear-producing countries of Europe include France, England, Belgium, and Germany. Of these, France is the greatest producer.[48]

Other pear-producing districts of the world include the Rio Negro Valley of Argentina, South Victoria and southwestern Tasmania in Australia, South Africa, and different parts of eastern Asia--Japan, China, Chosen, and Manchuria.

Commercial pear production is confined either to districts which are near large bodies of water (the Great Lakes), or to sections having cool, moist climates.[49] Regions without hot summers and extremely cold winters, with freedom from late spring frosts, are best suited for pears. In the Central States commercial production is precarious owing to the lack of an equable climate and the presence there of blights and pests.

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47 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 377.

48 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 411.

49 Thomas J. Talbert and Andrew E. Murneek, Fruit Crops, Lea and Febiger, 1939, p. 218.

In the southern states the climate is usually too hot for best development of tree and fruit. In the northern plains the winter temperatures are too low. In the warmer, drier interior regions the bacterial disease commonly known as fire blight is most injurious to the trees.

Pears will grow on a variety of soils, but deep clay loams are preferred. Soils which are very rich are not considered favorable; those lower in fertility are better adapted to the control of fire blight.

Usually the common pear is propagated by budding on French seedlings in the eastern states, while on the Pacific Coast propagation is on Japanese pear seedlings,--a variety not as subject to fire blight as European seedlings. In three or four years the first crop is borne by the tree; commercial bearing, however, does not occur until the fifth to seventh year. The pear bears annually for 50 to 100 years. On the average from 300 to 600 bushels of pears per acre is averaged by mature trees.

In general, the pear is a more perishable fruit than the apple. The time of picking must be timed so that the fruit will ripen properly before it comes into the hands of the consumer. The fruit should have attained sufficient size and color, and should show a faint yellowish tinge; for eating purposes the fruit is always handpicked. In the West two pickings are usually made while in the East the fruit is gathered at one

time.

For canning purposes, the fruit is allowed to become fully ripened on the trees.

When pears are to be shipped eastward, they are sorted, sized by machine, wrapped, and packed systematically in boxes or baskets.

In 1935 the United States produced 21,255,000 bushels of pears.[50] The United States is served mainly by its own orchards; but during March and April some are imported from Argentina. Northwestern Europe, especially Great Britain, France, and Sweden, is served by exports from the United States during the months of August, September, and October; by Argentina during March and April. The normal British market is supplied by fruits from France, Belgium, United States, Argentina, and even Cape Town, South Africa.

The Plum. See pages 374 to 381.

GUMS AND RESINS

Oleoresins

Canada Balsam. An oleoresin known as Canada balsam is secreted by the balsam fir (Abies balsamea),[51] a native of Canada and the northern parts of the United States. This fir is

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50 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 442.

51 Ibid., p. 185.

typical of cold climates and well-drained, moist situations; ranging from sea level to elevations of over 5600 feet, it grows in New England and Labrador west and north across New York, the Lake States, and Ontario to a few degrees of the Pacific Ocean at the headwaters of the Yukon River.[52] Commercial sources of balsam fir are Maine, Vermont, Minnesota, Wisconsin, New Hampshire, Michigan, Virginia, and New York.[53]

A resin collects in elongated blisters on the bark of the tree and only small amounts are obtainable. A tree is estimated to yield 5 to 10 ounces a year. Collectors use a pot with a spout cut at an angle. This is forced into the blisters and held in place while the balsam drains out--a greenish yellow, transparent, sticky fluid which dries into a transparent mass.

The chief uses of Canada balsam are as a medium in which to mount material on microscopic slides, as a cement for optical lenses, and in pharmacy because of its medicinal value--as an irritant, stimulant, and antiseptic; it is a component of collodion and many plasters. For these many uses the United States imported 7,872 pounds of crude Canada balsam from Canada in 1935.[54]

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52 George H. Collingwood, Knowing Your Trees, American Forestry Association, 1941, p. 70.

53 Ibid., p. 71.

54 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 193.

Spruce Gum. Various spruces of northern United States and Canada produce a natural exudation called spruce gum, but Picea rubens is the chief source.[55] Picea rubens has a broad range, extending from Labrador, Newfoundland, and Nova Scotia southward through New England, northern New Jersey, Pennsylvania, and along the Appalachian Mountains to northern West Virginia. In the lake states it occurs in Michigan, Wisconsin, and northeastern Minnesota, and thence from Hudson Bay and southern Manitoba northwestward in a broad belt to the west coast of Alaska.[56] Toward the northern limits the tree is reduced to shrub size.

Picea is a moisture-loving species and it inhabits cold sphagum bogs, springy swamps, and lake shores.[57] It is also found on sandy or rocky hillsides and uplands but only if the moisture is sufficient. It grows at elevations from one hundred to thirty-five hundred feet above sea level. Though it will grow on glacial drift and clay soils, the best growth occurs in well-drained alluvial soils that are constantly moist.[58]

A thin, clear, bitter, sticky oleoresin is secreted in blister-like cavities in the bark or in longitudinal fissures

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55 Op. cit., p. 186.

56 George H. Collingwood, Knowing Your Trees, American Forestry Association, 1941, p. 48.

57 Ibid., p. 48.

58 Ibid., p. 48.

in the wood. This exudation hardens on exposure to the air and is then collected either when hard or semi-soft. About 500,000 pounds are collected and used each year as a masticatory--spruce chewing gum.[59] Though the resin may be hard when collected, in a month it softens and assumes a reddish color. The gum made from it has a pleasing resinous taste.

ESSENTIAL OILS

Oils of Juniper, Savin, and Red Cedar. Three species of juniper--Juniperus communis, J. sabina, and J. virginiana--are sources of essential oils.

The "berries" of the common juniper (Juniperus communis)[60] are used as a flavoring material. This species of juniper is a small tree with evergreen needle-like leaves and berry-like cones. The tree is a native of the cooler parts of Asia, Europe, and North America.[61] The berries have a sweetish pulp with a characteristic gin-like aroma. They are purple in color with a greenish bloom. When dried, they are used in flavoring meats, but more particularly gin.[62] A volatile oil is extracted from the crushed berries by steam distillation and is also used for flavoring gin, and to some extent in medicine. This

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59 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 186.

60 Ibid., p. 476.

61 Ibid., p. 477.

62 Ibid., p. 477.

oil is prepared chiefly in Great Britain, Germany, and Hungary.

Oil of Savin is a medicinal oil and is distilled from the leaves of J. sabina.

The wood of Juniperus virginiana yields the essential Oils of Red Cedar used in perfuming soaps; the berries possess medicinal values and are used to flavor gin. This species frequently punctuates pastures, abandoned fields, dry gravelly slopes, rocky ridges, limestone outcroppings, and even swamps and lake borders over most of the eastern half of the United States from the Atlantic seaboard to the Great Plains.[63] On the poor soils in the northern part of this region the tree scarcely becomes larger than a bush, but in the south it may attain a height of 120 feet. Some live to be 130 to 150 years old; larger ones live 300 years or more. This valuable tree is native to the dry soil from Nova Scotia to South Dakota and southward to Georgia and Texas.[64]

The leaves and twigs of Juniperus virginiana when distilled furnish the valuable cedar oil. The dark purplish blue berries covered with a white powdery bloom are crushed and the oils obtained by distillation are used in medicine and flavoring gin. These crops of berries are abundant every two or three years.[65]

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63 George H. Collingwood, Knowing Your Trees, American Forestry Association, 1941, p. 98.

64 Ibid., p. 98.

65 Ibid., p. 99.

Oil of Sassafras. See the discussion under Sassafras below.

FLAVORING MATERIALS

Oil of Juniper. Flavoring materials are obtained from Juniperus communis and J. virginiana which grow in abundance in eastern United States. For the discussion of these two trees and the oil obtained from them for use in flavoring see pages 515 and 516.

Sassafras. Sassafras is a flavoring material of considerable importance. It is obtained from the bark on the roots of Sassafras variifolium, a native of eastern North America.[66] The natural range of this tree is from southern Maine to Ontario in southern Canada and south over the Mississippi Valley to east Texas and central Florida.[67] The largest of these trees are found in the deeper soils of the Smoky Mountains in Tennessee, Virginia, and North Carolina.[68]

The spicy root bark was used by the Indians and early settlers and their supposed medicinal virtues made it one of America's chief exports in colonial days. Today oil of sassafras is distilled by steam from the bark of the roots and to a less

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66 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 470.

67 George H. Collingwood, Knowing Your Trees, American Forestry Association, 1941, p. 168.

68 Ibid., p. 168.

extent from the wood. For this, the bark is gathered in the spring or fall, deprived of the outer corky layers, and dried, later to be distilled. The principal supply of this bark comes from Virginia, Tennessee, and Kentucky.[69] The oil of sassafras is used for flavoring tobacco, patent medicines, root beer and other beverages, soaps, perfumes, and gums.[70] Both the bark and pith are used in medicine. The oil is one of the sources of artificial heliotrope.

SUGAR

Maple Sugar. Maple trees yield considerable addition to the sugar supply of the North American continent. However, the sap from the sugar or rock maple tree (Acer saccharum) is the chief source of maple syrup and maple sugar. This tree furnishes about 80 to 95 per cent of all the maple syrup and sugar.[71] The remainder is obtained from several other species of maple: silver or soft maple (Acer saccharinum); red maple (Acer rubrum); and ash-leaved maple (Acer negunda).

Most of the northeastern highlands of North America is the natural home of the sugar maple.[72] Though now the sugar maple

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69 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 470.

70 Ibid., p. 470.

71 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 381.

72 J. Russell Smith, Men and Resources, Harcourt, Brace and Company, 1937, p. 48.

tree is found growing from Newfoundland to Manitoba and southward to Florida and Texas, the use of the tree for making syrup and sugar is restricted to the Northeastern Highland Region of North America, especially the northeastern states of the United States and the adjacent provinces of Canada, involving the St. Lawrence Valley: in the United States, Maine, New Hampshire, Vermont, New York, Pennsylvania, and Ohio are centers for the production of maple syrup and sugar;[73] in Canada, the provinces of Quebec, Ontario, and New Brunswick produce these products.[74] The combined production of this entire region yields annually between 8 million and 12 million pounds of maple sugar, and 3 to 4 million gallons of maple syrup.[75] Canada produces annually about five times as much maple sugar as the United States and about one-half as much syrup. This supply is only one-half of what it was in the middle of the past century. The ever lessening number of trees has resulted in the diminishing of the supply, the total industry in the late 1930's amounting to only 5 to 6 million dollars in normal years;[76] the hurricane of 1938 did great damage to the sugar maples of Vermont and the other

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73 J. Russell Smith and M. Ogden Phillips, North America, Harcourt, Brace and Company, 1940, p. 179.

74 Ibid., p. 179.

75 Ibid., p. 179.

76 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1935, p. 356.

New England states.[77]

The maple sugar industry is an example of native tree-crop agriculture, an industry already in full operation and capable of much extension, providing at present provision of a cash crop for farmers of the Northeastern Highland Region of North America.[78] Within this region the farmers have hill farms of many maple trees which are called "groves", "orchards", "camps", "woods", or "bush"--all varying in sizes--a large "camp" containing as many as 40,000 trees. It isn't the number of trees that is essential for good production, but rather the spread of the trees, for the leaves are the sugar factories and the sunlight their power; the greater the branch spread and number of leaves, the greater the amount of syrup and sugar produced.[79] The trees are readily planted in the form of new groves, and it is easily reproduced naturally so that there should always be little difficulty in maintaining sugar groves for the future of this industry.

The sugar maple trees used in the production of the maple syrup and sugar are those which are located in regions where there is an early spring of moderately warm days of bright sunshine and cold frosty nights with temperatures at night below

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77 J. Russell Smith and M. Ogden Phillips, North America, Harcourt, Brace and Company, 1940, p. 179.

78 Ibid., p. 179.

79 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 384.

freezing; this alternate freezing and thawing is peculiar to the climatic conditions of early spring in New England and is conducive to commercial sap flow.[80] Temperatures of 25° F. during the night and a maximum of 55° F. during the day with damp, northerly or westerly winds are conditions under which the best flows are obtained.[81] This causes the sap to flow up and down the tree each day and produces much more sugar than is produced in southern lands where the spring is warmer. These changes of temperature cause a certain expansion and contraction of gases within the cells and intercellular spaces in the wood which results in alternate pressure and suction to give free flow up and down the tree.[82]

Sugar maple trees grow in a wide range of soils, being found on most well-drained soils as well as on gravelly dry hillsides. As a result, groves are to be found on level land, on slopes, and on some ridges. Sloping land has the advantage for use of pipe systems in carrying sap from the "bush" to the sugar mill.

The commercial gathering season begins about the middle of March and lasts till near the end of April in the region from Vermont westward to include northern New York; in Ohio and west-

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80 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 382.

81 Ibid., p. 383.

82 Ibid., p. 383.

ern New York the season usually lasts from late February to early April.[83] The beginning of the sap season is determined wholly by weather and latitude.[84] The longest run on record is 57 days and the shortest, only 9 days; the average is about 34 days.[85] The gathering season ends when leaf buds begin to swell.[86]

The trees are tapped, just before the season opens, by drilling into the trunk of the tree about four feet above the base one or more small holes, drilling only into the first three inches of sapwood,[87] since most of the sap flow comes from the first three inches of sapwood. A spile or trough is driven into each hole to conduct the sap into the bucket as it flows up the tree. The trees are tapped on the southerly side of the tree because that side warms up earliest in the season and the first sap flow is considered the best. Two men tapping and hanging buckets for eight or nine hours per day can work 400 to 500 of these holes. Usually only one hole is made on a tree during a single gathering season.

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83 James B. McNair, Sugar and Sugar-Making, Field Museum of Natural History, 1927, p. 24.

84 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 383.

85 Op. cit., p. 24.

86 Op. cit., p. 384.

87 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p.

The sap is collected into old-fashioned buckets and modern galvanized-iron and tin buckets equipped with lids; the greatest flow of sap occurs between 9:00 A. M. and noon.

The gathering of sap from buckets was formerly done entirely by hand, the men going from tree to tree with buckets into which the new sap was poured from the pails hanging on the trees; with the development of larger commercial operations a gathering tank of from 25 to 160 gallon capacity is placed on a sled which is drawn by a team; pipe lines are now used to some extent in sugar orchards under such favorable conditions as large number of trees, rather steep topography, and a central location for the sugar house. Two collections are made during the day; gathering should be made as frequently as possible because leaving the sap too long in the buckets results in a discolored sap, which means a low-grade syrup.

The sugar camp or sugar house where the maple syrup and sugar are made from the sap is located with reference to minimum length of sap haul from the orchard. On well-drained slopes it may be at the base to permit emptying of the gathering tank by gravity into storage tanks. Then the sap is boiled down in modern evaporators to a heavy syrup or longer to give sugar.

The yield of sap differs with season, size of the tree, character of the tapping, and many other conditions.[88] A tree

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88 James B. McNair, Sugar and Sugar-Making, Field Museum of Natural History, 1927, p. 24.

averages from five to forty gallons of sap yearly, from two-fifths to one gallon of syrup, or one to seven pounds of sugar (maple).[89] A standard "bush" of 500 buckets yields about 6400 gallons of sap, equivalent to about 200 gallons of syrup, or 1500 pounds of sugar.[90]

With the advent of cane sugar, maple syrup and sugar ceased to be an important commodity on the markets, and now is classed as a luxury. The demands for both the syrup and sugar has kept the industry alive, but for the past three decades the production remained stationary because of the large amount of adulteration--approximately seven-eighths is estimated to be adulterated before it reaches the ultimate consumer. Organizations to combat this evil and place the products directly into the hands of the consumer, as well as standardize and advertise their product, have done much good work for this industry--especially the Vermont Sugar Makers' Association.[91]

Vermont has specialized more in the production of maple sugar than any other section, and Ohio turns out syrup for the market almost entirely; smaller quantities of each are produced in New York, Pennsylvania, and Michigan. The census for 1929 reports the production of 13,285,000 pounds of syrup and sugar

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89 Op. cit., p. 25.

90 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 397.

91 Ibid., p. 398.

valued at $2,509,000 from these states.[92] Most of it is used as a table luxury and for use in flavoring preparations, confections, etc. The inferior sugar and poorest syrup, sometimes called "black strap", is utilized for sweetening chewing tobacco.

TANNING MATERIALS

Chestnut Oak Bark. The oaks have always held a prominent position as a source of high-grade tanning materials because of the excellent nature of their effect on various skins. The bark of the chestnut oak (Quercus prinus)[93] is not only used directly in tanneries, but is also widely employed for making tannin extract. This oak is the most important tannin-producing oak in the Humid Continental climatic zone.

The chestnut oak is native to eastern United States along the southern Appalachian Mountain region, from southern Maine westward through Ohio and southern Indiana and southward through Kentucky and Tennessee to northeastern Mississippi and Georgia.[94] It is found most abundantly in Virginia, West Virginia, Tennessee, North Carolina, Kentucky, and southern Pennsylvania, in order of their importance.

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92 George H. Collingwood, Knowing Your Trees, American Forestry Association, 1941, p. 189.

93 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 64.

94 Op. cit., p. 154.

This tree does not grow in pure stands, but is associated with a number of other oaks and hardwoods, growing chiefly on the northern and eastern slopes of the mountains.[95] Although the chestnut oak is generally associated with dry soil and sandy rocky ridges, it frequently grows on rich, well-drained soil close to the banks of streams.

The trunk and large limbs have thick, nearly black bark, rich in tannin (8 to 14 per cent).[96] Its bark is exceedingly ridged, some indentations often being three inches deep. The peeling operations are carried on generally in spring, when the sap is flowing freely so the bark will slip off easily,--from late in March to the middle of June or later.[97] The general plan of peeling the bark of the chestnut oak is very similar to that employed in obtaining the hemlock bark.

Many tanneries have been established in western Virginia and West Virginia where the chestnut oak trees are most abundant.[98]

A cord of bark may be obtained from four trees averaging sixteen inches in diameter at breast height.[99]

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95 Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 71.

96 Ibid., p. 64.

97 Ibid., p. 71.

98 Ibid., p. 71.

99 Ibid., p. 72.

Hemlock Bark. From the earliest time the hemlock (Tsuga canadensis) has been the chief domestic source of tannin in the United States.

This species of hemlock features the forest and open country on cool moist slopes and in well-drained, fertile valleys throughout the northeastern states from northern Maine to northeastern Minnesota, south through Wisconsin, southern Michigan and Indiana, and southward along the mountains from Pennsylvania and West Virginia into northern Alabama and Georgia. The principal producing centers of importance are Pennsylvania, Wisconsin, Michigan, New York, West Virginia, and Maine; these six states produce over 90 per cent of the total hemlock bark production of the country.

Harvesting is carried on when the bark will slip off most easily. The spring of the year when the sap is flowing freely and the leaves are breaking out is the very best time for removing the bark.[100] In the northern portion of the hemlock region the season is often from early in May to early in July, whereas in the southern portion of the belt the season may be from April to June.[101] Peeling is accomplished much more rapidly during the warm damp weather within the peeling period, and even better during the morning and evening than during the noon

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100 Op. cit., p. 67.

101 Ibid., p. 67.

period.[102]

The bark is removed from the trunk of the tree by cutting circular rings at four foot intervals up the trunk and by prying off the bark after the bark is split from ring to ring. The trees are felled to facilitate the removal of the bark. Following the removal of the bark, the pieces of bark are leaned against the trunk to season, generally from one week to a month, depending upon the weather conditions. When merchantably dry, the bark is hauled out of the forest to the nearest loading point.

Hemlock bark contains 8 to 14 per cent tannin. It is used for sheepskins and for sole and other heavy leather.[103] Extracts are also available with a tannin content as high as 28 to 30 per cent.

Quercitron. Black oak (Quercus velutina) or yellow oak has recently come into prominence as a source of tanning materials, especially by the manufacture of an extract called "Quercitron".[104] Its center of production is in Pennsylvania and the southern Appalachians.[105] (For the geographical distribution and habitat of this tree see the same topic under Dyes and Pig-

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102 Op. cit., p. 67.

103 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 135.

104 Op. cit., p. 78.

105 Ibid., p. 78.

ments on page 496.) The tree yields a fairly thick bark and has a tanning content of from 6 to 12 per cent.[106] It is produced in the same manner as the bark of the hemlock (See page 527.). Its principal drawback is that it mildews easily and care must be exercised in the drying process and in stacking in the woods. Leather made from it has a violent yellow color. The total output is relatively small as compared with other barks.

TREE LEGUME AND EDIBLE NUTS

Tree Legume

Honey Locust. The honey locust (Gleditsia triacanthos) is a cousin of the carob tree.[107] J. Russell Smith believes it offers a great crop possible to a million square miles of eastern United States in the climates of corn and cotton.[108] The honey locust, like the carob, is an important stock-feed tree. It bears conspicuous broad, flat, bean-like pods which are often six to eighteen inches in length. These pods hang close together on the tree, as close as fingers on a person's hand. The mature pods are black. Their sweetness is due to the honey lying in the sweet pulp of the thicker part of the pod and the

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106 Op. cit., p. 64.

107 J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p. 62.

108 Ibid., p. 62.

beans in the thinner part.

The honey locust is native to the alluvial valleys from Ontario to Texas in the humid eastern part of North America. The species grows abundantly west of the Appalachian Mountains in the humid portion of the corn and cotton belt from New York to eastern Nebraska, and from northern Louisiana to southern Minnesota.[109] This belt climatically involves the northern part of the Humid Subtropical, but more importantly the Humid Continental of the Long Summer Phase.

The tree thrives best in humid regions of moderate rainfall and alluvial soils.[110] Experiments have shown that the tree can be adapted to stand considerable drought and low temperatures; that it will grow well on high tableland where the rainfall is only about sixteen inches; it has also been found that it will grow on soil that is alkali.[111]

A mature honey locust tree will produce as much as ten to twenty bushels per tree,[112] an amount which would equal one to two tons per acre if planted twenty trees to the acre.[113]

The pods of the honey locust appear on the trees at an

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109 George H. Collingwood, Knowing Your Trees, American Forestry Association, 1941, p. 180.

110 J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p. 62.

111 Ibid., p. 63.

112 Ibid., p. 66.

113 Ibid., p. 68.

early age, but large crops seldom occur before three to five years.[114] The pods mature in autumn and hang on the trees until early winter. If allowed to remain on the trees until winter, the pods have the tendency to curl up; and this makes harvesting possible with the use of a rake.[115]

Since the pods contain 29 per cent sugar, thay are an excellent feed for animals and cattle. The animals may eat them directly from the trees in the field, or the crop may be harvested for winter forage to serve as a bran substitute.

The honey locust has a number of qualities which favor giving it serious attention as a cultivated crop: it is a rapid grower; its open top favors its use in two-storied agriculture; it has high productivity per tree; it bears with greater regularity than most fruit or nut trees; it is extremely useful in preventing gullying by holding in place the land on the hills by means of its roots.[116] For all these reasons the honey locust is more than worthy of extensive investigation and experiment.

Edible Nuts

Beechnuts. Beechnuts are the shiny triangular seeds or

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114 George H. Collingwood, Knowing Your Trees, American Forestry Association, 1941, p. 181.

115 J. Russell Smith, Tree Crops: A Permanent Agriculture, Harcourt, Brace and Company, 1929, p. 67.

116 Ibid., p. 65-67.

nuts of the American beech tree (Fagus grandifolia)[117] and the European beech (Fagus sylvatica). The beech tree is one of the trees characteristic of the mixed deciduous hardwood forests within the Humid Continental type of climate featuring the Long Summer Phase, where the annual rainfall exceeds thirty inches, with more than half falling during the warm months.

In North America Fagus grandifolia is a native of the forests from southern Canada, northern Michigan and eastern Wisconsin to the Atlantic, and south to eastern Texas and northern Florida, often forming nearly pure stands.[118] It attains largest size in the rich, alluvial bottomlands of the Ohio and the lower Mississippi River valleys, and along the western slopes of the southern Appalachian Mountains.[119]

Fagus sylvatica is native to and common throughout the valleys of central Europe.[120]

The American beechnuts are small, triangular, and very sweet while the European beechnuts are slightly larger. Though the sweet flavor is excellent, the diminutive size and shape have limited its use as a human food. However, they are eagerly

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117 George H. Collingwood, Knowing Your Trees, American Forestry Association, 1941, p. 128.

118 Ibid., p. 128.

119 Ibid., p. 128.

120 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 381.

eaten by pigs and the wild boars of the European forests.[121] When hogs are fed on mast consisting of a mixture of beechnuts, chestnuts, and acorns, the pork of the animal has a fine flavor. The larger nuts of the European species are eaten and used for the edible oil of beechnut.

Black Walnut. The black walnut (Juglans nigra) is one of the chief trees common to the eastern deciduous forest region of the United States and southern Ontario.[122] The tree can be grown anywhere within that region, but attains its best growth in the deep rich well-drained alluvial soils where the moisture is plentiful.[123] The part which best favors the growth of this tree includes the states from Maryland, Pennsylvania, and Virginia, west into eastern Iowa and Missouri.[124]

The tree is becoming more and more important for the nuts which it produces. These are large spherical fruits which are green when ripe, the outer cover of which has to disintegrate or be beaten off to free the nuts inside. The nuts mature in a single season, during September and October. The walnut kernels contained in the nut are rich in oil. They are used by confectioners, bakers, and makers of ice cream, because the dis-

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121 Op. cit., p. 381.

122 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 399.

123 George H. Collingwood, Knowing Your Trees, American Forestry Association, 1941, p. 103.

124 Ibid., p. 102.

eaten by pigs and the wild boars of the European forests.[121] When hogs are fed on mast consisting of a mixture of beechnuts, chestnuts, and acorns, the pork of the animal has a fine flavor. The larger nuts of the European species are eaten and used for the edible oil of beechnut.

Black Walnut. The black walnut (Juglans nigra) is one of the chief trees common to the eastern deciduous forest region of the United States and southern Ontario.[122] The tree can be grown anywhere within that region, but attains its best growth in the deep rich well-drained alluvial soils where the moisture is plentiful.[123] The part which best favors the growth of this tree includes the states from Maryland, Pennsylvania, and Virginia, west into eastern Iowa and Missouri.[124]

The tree is becoming more and more important for the nuts which it produces. These are large spherical fruits which are green when ripe, the outer cover of which has to disintegrate or be beaten off to free the nuts inside. The nuts mature in a single season, during September and October. The walnut kernels contained in the nut are rich in oil. They are used by confectioners, bakers, and makers of ice cream, because the dis-

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121 Op. cit., p. 381.

122 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 399.

123 George H. Collingwood, Knowing Your Trees, American Forestry Association, 1941, p. 103.

124 Ibid., p. 102.

tinctive flavor and texture is not lost in cooking.[125] They are not, however, used much as table nuts.

The black walnut tree has great possibilities as a producer of food and will probably become more numerous with the increasing modern demand for nuts as there are many unused areas that could grow this tasty and nutritious product.[126]

Butternuts. Butternut, or white walnut (Juglans cinerea)[127] occurs as a native tree in the limestone areas of the eastern United States and adjacent Canada. More specifically it grows from southern New Brunswick and Maine through the upper peninsula of Michigan to eastern South Dakota, thence southward into northern Arkansas and the mountains of Alabama and Georgia.[128]

The trees develop pear-shaped sticky fruits whose pulpy covering or husk encloses a deeply ridged, oblong nut with a rich, sweet, oily kernel which gives the tree its name. The nuts ripen in October.[129] Butternut kernels are widely recognized as a food product and the immature nuts are occasionally

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125 Op. cit., p. 103.

126 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 380.

127 George H. Collingwood, Knowing Your Trees, American Forestry Association, 1941, p. 100.

128 Ibid., p. 100.

129 Ibid., p. 101.

pickled in vinegar, sugar, and spices. The meat of this nut is prized not only to eat fresh but as flavoring in confectionery and ice cream.[130]

The butternut tree was never abundant, and, while the nuts are rich in oil, they are difficult to gather and even harder to crack.[131] Several strains of rapid-growing trees capable of producing large quantities of easily cracked nuts have been reported, so that the butternut may find a real place among food crop trees in the future.[132]

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130 Ellsworth Huntington, Frank E. Williams, and Samuel Van Valkenburg, Economic and Social Geography, John Wiley and Sons, Inc., 1933, p. 380.

131 Ibid., p. 380.

132 George H. Collingwood, Knowing Your Trees, American Forestry Association, 1941, p. 101.

CHAPTER XVI

TREE CROPS OF THE MARINE WEST-COAST CLIMATE

The Marine West-Coast climate is not a large contributor of commercially important tree crops. Though the vegetation of regions having this climate is or has been essentially one of heavy forest growth, only three tree crops of any note are derived directly from this source: from the Pacific forests of North America, cascara (a drug) and western hemlock bark (a tanning material); and from the forests of New Zealand, kauri gum (a resin). This type of climate with its rainy, cloudy, cool weather, and its continually moist soils is not favorable for maturing and harvesting fruit crops; therefore, only a few of the hardier tree fruits--especially apples, pears, plums, and sweet cherries--are grown in any appreciable quantities, and then are largely confined to the protected valleys on the east slopes of mountain ranges in our Pacific Northwest.

DRUGS AND MEDICINAL PRODUCTS

Cascara. A familiar drug called cascara is obtained from the bark of the western buckthorn (Rhamus purshiana), a tree native to the forested mountain slopes of the Pacific Northwest. It is common in the forests of our northwestern states--in northern California, Oregon, and Washington--and in adjacent Canada--in British Columbia. A European species of buckthorn (Rhamus

frangula) yields a bark containing a drug similar in its properties to Rhamus purshiana.[1]

For commercial purposes the bark is peeled off in long strips during the spring and summer, and is then carefully dried on racks. The dried bark is kept a year before the drug is manufactured from it.

Cascara is imported in the form of quills or curved pieces of bark of varying sizes, from Europe and British Columbia to supplement our own production of the bark. The United States imported 98,342 pounds of cascara bark in 1938.[2] Stringent regulations made in this country to prevent the destruction of our trees is responsible for this large import.

The drug has valuable purgative and tonic properties. Therefore, cascara is used in the manufacture of tonics and laxatives.

FRUITS

The Apple. See pages 497 to 505.

The Cherry. See pages 505 to 509.

The Pear. See pages 509 to 512.

The Plum. See pages 374 to 381.

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1 Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 262.

2 Ibid., p. 278.

GUMS AND RESINS

Kauri Gum. Kauri gum or kauri copal is one of the most valuable of the hard resins. This important varnish resin is derived from the kauri or cowrie pine--Agathis australis[3]--New Zealand's largest and most important tree.

The resin or copal is chiefly fossil in nature and is dug up from the soil on ridges and in swamps and boggy ground where the kauri pine formerly grew.[4] This "swamp gum" is the source of the bulk of the supply,[5] and pieces range in size from one or two inches in diameter to lumps weighing one hundred pounds.

Large forests still exist and a small amount of fresh resin is obtained by tapping the living trees.[6] This "bush gum" which is obtained from living trees is inferior to fossil forms.

It is estimated that the gum-producing area covers a total of about 800,000 acres, but the industry is now under government control and the main supplies are obtained from reserved areas.[7]

Kauri gum is yellow, transparent, and very hard. It is an exceedingly valuable varnish resin, especially for marine and outside work. It is also used in making linoleum.

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3 Op. cit., p. 173.

4 Ibid., p. 173.

5 Ibid., p. 173.

6 J. Henry Vanstone, Raw Materials of Commerce, Sir Isaac Pitman and Sons, Ltd., 1929, p. 305.

7 Ibid., p. 305.

Kauri is one of the chief exports of New Zealand. Large quantities are exported to England and the United States for use in the varnish and linoleum industries.[8] For these uses the United States imported 1,386,821 pounds of kauri gum in the year 1935.[9]

TANNING MATERIALS

Western Hemlock. Two species of western hemlock (Tsuga heterophylla and T. mertensiana),[10] trees of increasing economic importance, constitute an important resource of tannins and seem destined to be one of the chief native sources of tanning materials of the future for the United States. So far the prohibitive cost of shipping western hemlock bark to the eastern tanning factories precludes its wide use throughout the country; and the tanning industry has been little developed in the northwest where these trees are found.

The western hemlock is found in the deep forests of the humid coast regions from Prince William Sound in Alaska for a thousand miles to Main County in California, just north of San Francisco, and inland as far as northern Idaho and northwestern Montana.[11] It grows best in this region in cool, moist loca-

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[8] Op. cit., p. 305.

[9] Albert F. Hill, Economic Botany, McGraw-Hill Book Company, Inc., 1937, p. 193.

[10] Nelson C. Brown, Forest Products: Their Manufacture and Use, John Wiley and Sons, Inc., 1919, p. 77.

[11] George H. Collingwood, Knowing Your Trees, American Forestry Association, 1941, p. 64.

tions on the seaward side of the Cascade Mountains, at elevations from 1500 to 3500 feet above sea level, but ascends to altitudes of 6000 feet.[12] The percentage of tannin content in the bark increases with increase in elevation.

The peeling season for western hemlock often begins as early as February and the season usually runs from May to August of each year. The process follows the same general plan for eastern hemlock. Owing to the very rainy climate, the bark seasons out with some difficulty. It is handled, treated, and used in the same way as eastern hemlock.

It has been estimated that western hemlock supplies about two-thirds of the present annual requirement of the tanneries in the northwest. With the further development of that rapidly section, and the installation of more and larger tanneries, it is believed that western hemlock will assume greater importance as a source of tanning materials.

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12 George H. Collingwood, Knowing Your Trees, American Forestry Association, 1941, p. 64.

CHAPTER XVII

CONCLUSIONS

This thesis has attempted to prove that the variety of tree crops and the multitude of uses for which they are employed are more extensive than a casual consideration would lead one to believe. In fact, it might be concluded from this study that tree crops constitute a basic part of man's daily life. Without trees he would be deprived of a great variety of products which add to his welfare and comfort, among which are beverages, drugs and medicinal products, dyes and pigments, fibers, fruits, gums and resins, latex products, masticatories, oils and waxes, spices and flavoring materials, tree legumes and edible nuts, vegetable ivory, and cork. These products are derived from various parts of trees: from the fruits, nuts, beans, berries, flower buds, seeds, leaves, blossoms, bark, latex, and juices of trees.

The existence of tree crops depends upon the favorable growth of trees; and climate--principally temperature and rainfall-- is most often the sole determining factor for tree growth in any part of the world. All trees show particular adaptations to the climatic regions of which they are native, and so more than anything else climate determines the regions in which they may be cultivated. Only three climatic regions are conspicuous by their lack of tree crops, and in each climate is

the forbidding factor--the Polar Continental, the Subpolar, and the Polar Ice Cap climates. Of the remaining climatic zones, tree crops are most abundant where temperature and rainfall are in close harmony. The three most productive climatic regions, as far as the number of commercially important tree crops is concerned, are the Tropical Rainy, the Humid Subtropical, and the Mediterranean Subtropical climates.

Though climate determines the tree crops of a region through its favorableness for tree growth, their exploitation for commercial purposes is either fostered or restricted by physiographic, economic, political, or social factors. As a result, many tree crops are yet unknown beyond their native habitats, and others remain untested and almost unexplored from the standpoint of economic botany.

Every climatic region which fosters tree growth contains crop-yielding trees which in future ye ars may be expected to assume commercial importance if political, economic, and social conditions favor their exploitation.

CHAPTER XVIII

ABSTRACT

The purpose of this thesis has been to present the economically important tree crops of the different climatic regions of the world in order to show man's present dependence upon them for his welfare and comfort. The tree crops taken under consideration consisted of fruits, nuts, beans, berries, flower buds, seeds, leaves, bark, latex, and juices of trees which grow in native forests and in a cultivated state in plantations and orchards. The geographical basis chosen for this study was climate, since climate is fundamentally responsible for the geographical distribution of trees. The climatic regions were analyzed as to the conditions favorable for the growth of crop-yielding trees; then within each climatic region the tree crops have been presented under headings indicative of man's major use of them: beverages, dyes and pigments, drugs and medicinal products, fibers, fruits, gums and resins, latex products, masticatories, oils and waxes, spices and flavoring materials, tree legumes and edible nuts, sugar and starches, tanning materials, and miscellaneous. Each tree crop is discussed as to geographical distribution, geographic factors underlying its production, its culture and preparation for market, and its economic importance.

A number of geographic factors combine to determine the

distribution and production of tree crops: economic, physiographic, political, and climatic factors. The economic factors influencing tree crop production are supply and demand, labor, and the time factors of gestation period, age commercial bearing begins, and the duration of yield. Physiographic factors which may restrict the localities of tree crop production are location--in respect to land and sea, in respect to main trade routes, in respect to the labor supply--soil, and topography. Existing political conditions may either foster or restrict tree crop production in a region despite the fact that climate favors its distribution there. Climatic factors fundamentally responsible for the distribution of tree crops include rainfall and humidity, temperature, wind, and sunlight. Of all the geographical factors, climate more than any other determines the possible areas where the tree crop may be produced; but the actual economic exploitation and production may be further limited by economic, physiographic, and political factors.

Therefore, in this geographic study of tree crops the basis of subdivision is climate. Of all the climatic regions of the world three are conspicuous by the total absence of tree crops, --the Polar Continental, the Subpolar, and the Polar Ice Cap climates. In each of these three temperature is the forbidding factor in tree growth. In all other climatic regions tree crops are present in varying numbers, depending on the combination of temperature, rainfall and humidity, wind, and sunlight.

Regions under the influence of the Tropical Rainy climate are the richest in crop-yielding trees. In general, optimum atmospheric conditions of temperature and rainfall exist in this climatic regime for the growth of trees and tree crops. Every major type of tree crop is to be found in this climate; numerous varieties of each type contribute to the length of the list. Many of these tree crops come directly from the tropical rainforests; others are cultivated on plantations or native farms.

The Monsoon Tropical (Tropical Savanna) climate has only seven tree crops of commercial importance since the number and species of trees possible in this climatic type are limited to those which are adapted in response to the distinct rainy and pronounced dry seasons which exist there.

There is but one tree crop of prominence in the Cool Tropical Highland climate--coffee. Though certain temperate fruits can be grown in regions having this climate, they are not of economic importance since their quality is poor due to the lack of influence of winter conditions which are needed in order for them to do their best.

Since the Semi-arid Tropical regions are lands of scanty rain which occurs only from one to three months of the year, few trees are able to exist there. Only five tree crops typical of this climate have attained commercial importance.

One tree crop--the date--is representative of oases in the

Arid Tropical regions of the world. The Arid Tropical climate is unfavorable to tree growth except where underground sources of water are available to make their growth possible in oases. Though other tree fruits, as pomegranate, apricot, olives, and even peach, may be found along with dates in this climatic type, they are only of minor importance here, having been introduced from the subtropical regions. The date is the dominant tree in the oases of tropical deserts and is "king of tree crops" there.

The Humid Subtropical climate is an important contributor of tree crop products. The prevailing climatic conditions of abundant rainfall, somewhat evenly distributed throughout the year, and moderate temperatures favor the growth of a wide variety of trees and so furnish man with a large number and variety of tree crops.

Regions under the influence of the Mediterranean Subtropical climate are rich in the number and variety of economically important tree crops which they produce. Those found within this climate are mainly of two types: the dry land type--those which are native to this climatic regime and so are naturally adapted to the prevailing summer drought of the environment; and the intensive irrigated type--those moisture-loving crops which have been introduced here from humid regions.

Climatic conditions are adverse to tree growth in regions having a Dry Subtropical climate; but because of their adaptability to arid and semi-arid conditions such as exist in regions

under the influence of this climate two tree crops--mesquite and piñon nuts--are to be found.

The two Humid Continental climates--the Long Summer Phase and Short Summer Phase--are similar in all climatic aspects with one exception--their length of summers. Therefore, the kind of trees and, naturally, the kind of tree crops in both are for the most part the same. Both of these climatic types are rich in the number of crop-yielding trees which exist within their bounds and provide man with a large variety of tree crops.

The Marine West-Coast climate is not a large contributor of commercially important tree crops. Though the vegetation of regions having this climate is or has been essentially one of heavy forest growth, only three tree crops of any note are derived directly from this source. This type of climate with its rainy, cloudy, cool weather, and its continually moist soils is not favorable for maturing and harvesting fruit crops; therefore, only a few of the hardier tree fruits are grown in any appreciable quantities.

The variety of tree crops and the many uses for which they are employed are more extensive than the average person realizes. From a study of this thesis it may be concluded that tree crops constitute a basic part of man's daily life. Without them he would be deprived of a great variety of products which add to his welfare and comfort.

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